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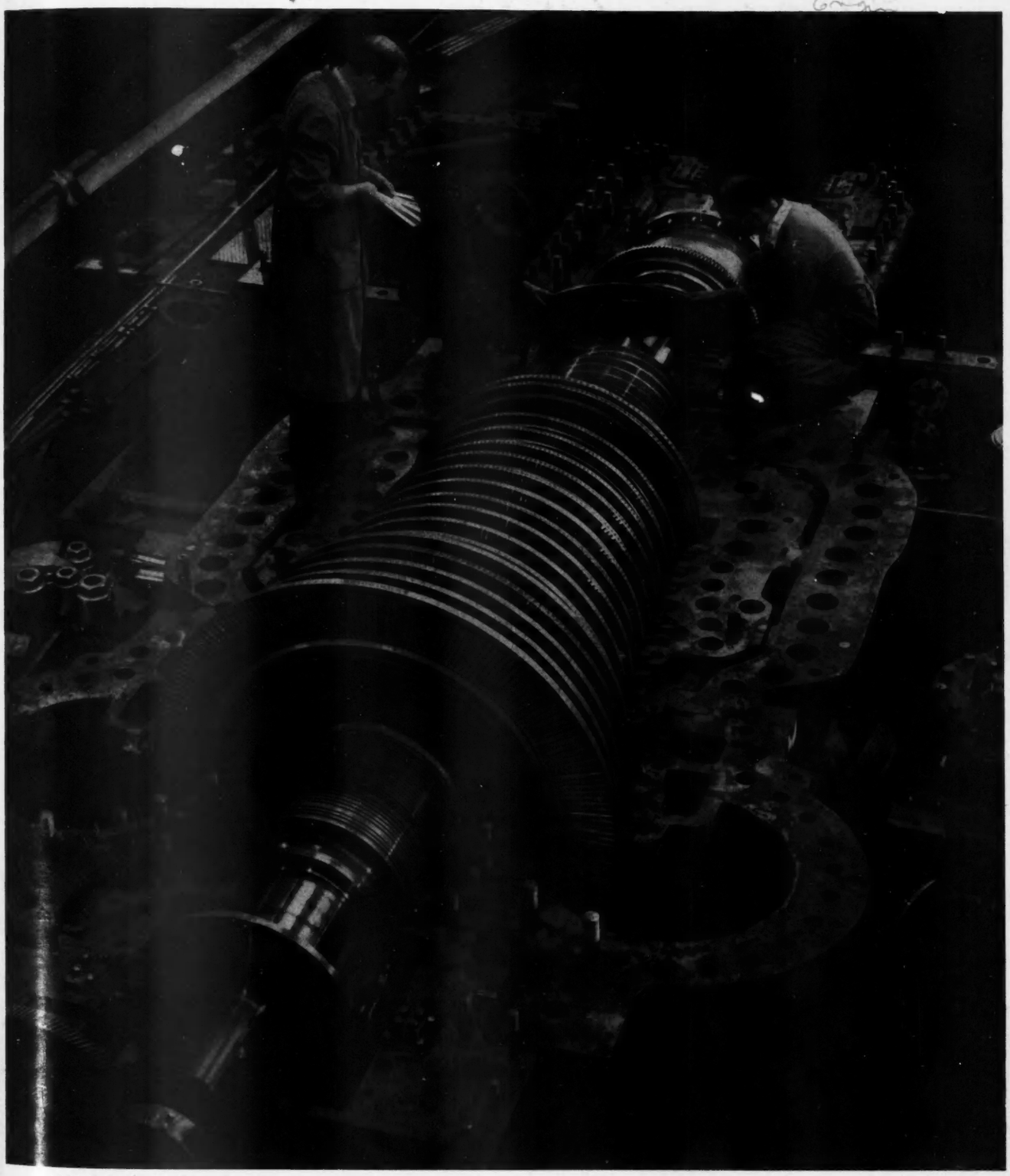

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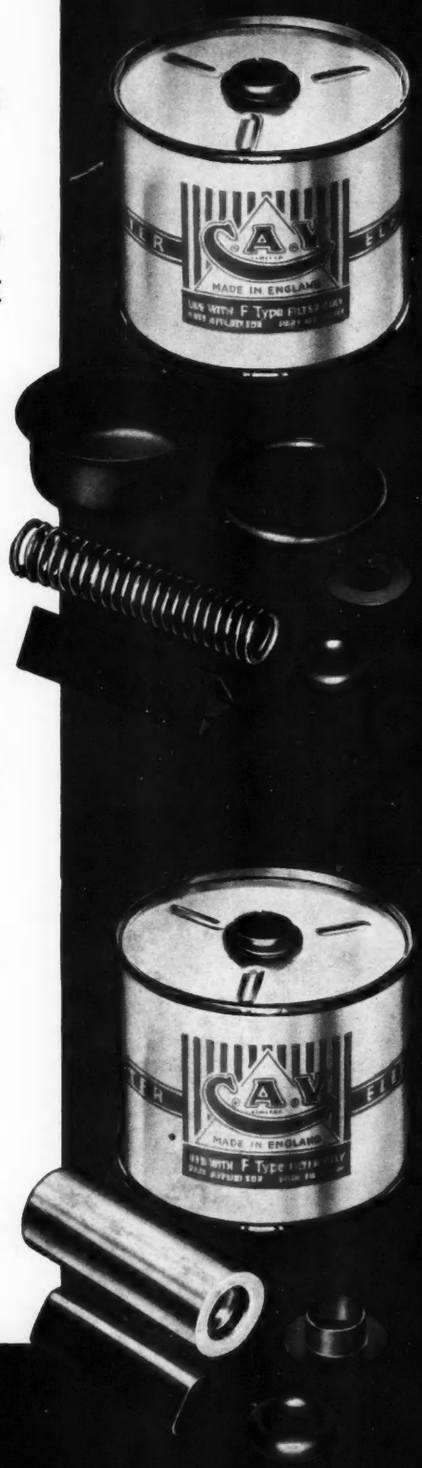

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THE ATOM AND THE OLIVE BRANCH

At the beginning of this year we published a leading article in which we attempted to discover how the young people of to-day responded to the problems of the atomic age. The leader was based on a discussion, and perhaps the most fruitful contribution was made by a schoolboy who suggested that peace could most easily be preserved if it were harnessed to individual self-interest in some way, as private aspiration and public prosperity were linked by the price system. It seemed then that the only way in which nuclear science could promote world peace was a negative one—as a deterrent; now, however, as we become more and more aware of diminishing coal stocks, as smaller countries less well endowed with natural fuels recognise their opportunity, and as the whole world awakens to its common need, so fission gives place to fusion and atomic energy is seen to be that cohesive power which may link the separate ambitions of nations to universal peace.

It is perhaps as the gateway to this new, more hopeful era that the International Conference on the Peaceful Uses of Atomic Energy at Geneva will best be remembered. The city of Geneva, set on the edge of a placid inland sea, has long been associated with the cause of peace. Ministers of state have gathered there on many occasions with the object of reducing international tensions; but seldom, if ever, can there have been a conference of the kind that opens next Monday. A political settlement may last a hundred years but knowledge revealed during the next fortnight may affect the whole course of human history. This international conference may prove to be the most lasting achievement of the United Nations Organisation, and this time it may be the smaller nations which provide the initiative.

No doubt the great powers have been curious about the progress of their neighbours in the field of atomic energy, but it is the little countries and the under-developed lands of Africa and the East which stand to profit most. Perhaps it is they that have provided the pressure that has led to the conference; and it is their pressure which may serve to forge the link with peace. As Dr. Bronowski remarked in a recent article in *The Observer*: "The silent pressure of their presence (in the United Nations) has created the new climate. . . . The smaller European countries, Britain among them, have led the surge of atomic power for peace; and behind them has stood the mutinous need of the under-developed countries." The countries without coal have seen a new prospect.

From the clean bright city of Geneva to the smoky industrial towns of the coal belt, from the pronouncements of nuclear physicists to the Lancashire saying "where there's muck there's brass" seems a far cry. Yet there is a very important connection. It has become almost a truism that power resources and a prosperous standard of living go hand in hand; comparisons have, for example, been made between the number of "power slaves" possessed by an average American and the corresponding numbers in other countries. Hitherto, these slaves were the exclusive genies of coal and oil, and where they were found there, too, riches abounded, together with liberal accumulations of dirt. But the development of nuclear energy can change all this. It is almost limitless in supply and clean in operation. It need not be hoarded for one's private use alone, for the production process can be a cumulative one. There is sufficient to give power for irrigating deserts and making arctic wastes fruitful. There is enough for all.

There is no evidence that nuclear power can be immediately attractive from the economic point of view. Indeed the investment required for its development is out of all proportion to short-term gains. But public confidence in scientific research as a form of investment has grown at a compound-interest rate during the past three or four decades, so that to-day governments and industries are ready to vie with each other in anticipating the stage at which, on a more reasonable estimate, it would be time to translate theory into practice. Meanwhile the relative costs of various forms of power will change slowly but surely in favour of nuclear power. The advantage may come to the under-developed nations first, but the advanced nations will then be ready with knowledge and experience of nuclear power stations.

The conference in Geneva will foster the release of new knowledge; the cross-fertilisation of ideas is always a rewarding process and the subjects to be discussed range over many fields. Papers submitted by 33 countries and various international organisations will cover such topics as medicine and agriculture, metallurgy and the benefits of irradiation, law and economics, the dissipation of effluents and the conversion of nuclear energy to electric power. Perhaps a practicable method of transforming the energy of the atomic nucleus directly into electric current—as a selenium cell reacts to light—will be revealed.

These contributions of the nuclear scientist may introduce an age of plenty, of cheap domestic heating, of corn resistant to blight; and plenty that is not limited to one nation or group of nations.

Weekly Survey

Cover Picture: *Checking the clearances between the stationary and moving parts of a steam turbine such as the 60 MW, 1,500 lb. per square inch, 1,050 deg. F. set illustrated on this week's front cover, is an operation requiring considerable skill. The fixed and rotating blades are separated by only a small fraction of an inch, and this distance may vary a little depending on whether the machine is hot or cold. Vibration is another factor which has to be taken into account and care is necessary to ensure that the steam and oil passages are free from scale and dirt before the machine is commissioned.*

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IRON AND STEEL PRODUCTION METHODS AND COSTS

Two papers published by the Battelle Memorial Institute, Columbus, Ohio, are of considerable interest to iron and steel producers. One, by Mr. John D. Sullivan, summarises recent work done in the United States to overcome the difficulties associated with the smelting of varying grades of iron ore, particularly the low grades which are having to be used increasingly as supplies of high-grade ores are run down. The other, by Mr. Hammett P. Munger, discusses cost factors in selecting processes for producing iron and steel.

Mr. Sullivan draws freely from literature on beneficiating techniques, particularly that published since 1940 on United States practices. Until recently the U.S. maker of pig iron has been able to use high-grade ore which required no pre-treatment, charging it with coke and limestone directly into a blast furnace in the reasonable expectation that nearly pure iron could be run out at the bottom. Since this has formed the basis of the world iron and steel industry it has come to be the accepted order of things. For many years in France and Germany with low-grade minette ore, and in the United Kingdom with similar low-grade ores from the counties of Oxford, Lincoln and Northampton, the same sort of smelting practice has been adopted. However, the proportion of impurity has risen and with it the burden of limestone flux and the amount of coke required to smelt the charge. In consequence the cost of smelting has gone up so much that the industry has sought ways of reducing the impurity in the raw material by a process described as beneficiation. This is, in fact, what has been done by the non-ferrous metal industry since these metals have been produced on a commercial scale. The producer of most non-ferrous metals does not expect to be able to dig a mineral out of the ground, charge it into a furnace with fuel and flux, blow air in through the bottom and then tap out the pure metal he requires. He will first separate a reasonable concentration of the mineral from the rock and other unwanted constituents in the ore. Although the lowest-grade iron ore used in the United States contains at least 30 per cent. iron, this, in effect, is the path which must increasingly be followed by pig-iron producers.

Mr. Munger also quotes a large number of sources, and draws on a wealth of data assembled by United Nations agencies. He develops a method for approximating the costs of pig iron, sponge iron and ingot steel, using production methods which are in commercial operation at the present time. His orderly and thorough consideration of the many factors involved—location of plant, raw materials available, cost of labour, beneficiation and sintering of ores, various smelting and refining processes, etc.—will serve as an admirable guide to what must be looked for and analysed to have the most efficient unit which local conditions permit. A point stated with great emphasis, that an integrated steel plant cannot be built on equipment and raw material alone but requires a good supply of local man-power which can provide a nucleus of skilled men, and that training facilities must be available, is one which is all too often overlooked.

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HARSH AND INESCAPABLE FACTS

The Rt. Hon. Viscount Bruce of Melbourne has issued, in his statement as chairman of the Finance Corporation for Industry, one of the bluntest warnings the nation has yet received in the life of the present Government. He said: "The first essential to my mind is to make the people as a whole understand how precarious is our economic and financial position and how vitally their employments and standards of living depend upon how we face it." In his view, which we wholeheartedly endorse, only a full-scale national effort can produce the desired results, namely reduced consumption and increased exports. Lord Bruce shows how foreign competition is steadily increasing, and how the British hold on world export markets, established during the post-war period of buyers' markets and in the absence of German and Japanese competition, is now being challenged. Before the war, Britain and Germany each had roughly a 20 per cent. share in world exports of manufactured goods. In 1951 Britain's share was 21 per cent. and Germany had built up her share to 9 per cent. In 1954 Britain's share had dropped to an estimated 19 per cent. and Germany's share had expanded to an estimated 14 per cent. There are no signs that Britain is currently improving her competitive position, but rather the reverse. Prices are being forced up by rising wages and raw materials costs, and Japan and the United States are striving hard to increase their exports. Lord Bruce may be "a prophet of gloom" but the Government are aware of the danger, and may do worse than follow his advice and tell the people in simple but forceful language what is required of them.

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LOFTY FINANCE FOR INDUSTRY

The Finance Corporation for Industry, Lord Bruce, also said, are effectively filling a gap in the financial mechanism of the country. They are debarred by their mandate from providing finance which can be found through the ordinary channels of the City, and, further, they are limited to action where they are convinced that "the venture is one that is in the interests of the national economy to develop." Notwithstanding these limitations, F.C.I. have, in the ten years of their existence, made or undertaken to make advances to an aggregate amount of £125 million. New business during 1954 amounted to £18¼ million and they expect that an even heavier call will be made on their services this year.

Lord Bruce defined the three main types of projects which qualify for his company's financial support as follows: first, the new venture which, because it is far forward in conception, finds it difficult to raise the capital it needs to start. The Steel Company of Wales, financed by the F.C.I. to the tune of £35 million without which, according to Lord Bruce, the project could not have been launched, is quoted as an example. Second, the company producing something likely to become indispensable to British industry or vital to the economy. Murgatroyd's, the salt and chlorine producers, and Petrochemicals are quoted as examples and both classified as considerable national assets. The latter were sold, at a heavy loss, to Shell and the former to I.C.I., presumably at a profit. In the case of Petrochemicals, F.C.I. were faced with the alternative of selling at a loss or injecting a further large sum of money together with taking up some measure of direct control as well as responsibility for the technical side of the business. This is not the Corporation's purpose in life and they are not equipped to do it. The third class of project is the small company making a product with an outstanding sales potential which needs capital to expand. The example quoted is F. Perkins, Limited, the Diesel-engine firm financed by F.C.I. until they made a public issue in 1951.

It is sometimes difficult to see the distinction drawn by Lord Bruce between the three types of project. In essence, F.C.I. take the plunge where others fear to dip in the big toe, provided of course that their staff and advisers consider the project stands a reasonable chance of doing well. The Corporation make money through capital appreciation, or the reverse if things go wrong. Their success should encourage the City to be more daring.

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POLYETHYLENE IN SCOTLAND

Scotland's dependence on the heavy industries goes back to the great days in the early development of coal and steel. It has been one of the features of Britain's post-war prosperity that this dependence is still very marked, despite the chronic depression which such dependence brought in the 1930's and the efforts which have been made since the war to diversify Scotland's economy. It has been clear for some time that the lines on which such diversification should take place, and where Scotland is significantly lacking as yet, is in electronics and the development of chemicals, including those from petroleum. Progress has been made since the war, notably in the development of chemicals. In the West of Scotland I.C.I. have been developing their interests at Dumfries not only with the production of "Ardil" but also in the development of resins by putting up a plant for the production of pentaerythritol.

In East Scotland, I.C.I. have also been developing their interests in the Grangemouth area, a growth which dates from its dyestuffs factory established after the first World War (although in those days I.C.I. as such did not exist). The decision announced last week by Union Carbide, an associate of the Union Carbide and Carbon Corp. of America, to produce polyethylene at Grangemouth is a further step in the development of petroleum chemicals in Scotland. The new plant is to be put up near the Grangemouth plant of British Petroleum Chemicals who will supply ethylene under long-term contract. Until now Imperial Chemical Industries have been the only producers of polyethylene in this country, and it may be significant that the I.C.I. patents for making this commodity by high-pressure polymerisation expire early next year, although there is a German low-pressure process in existence. Marketing of the plant's output at home and abroad will be in the hands of Bakelite Limited, in which the Union Carbide and Carbon Corporation in America have a large interest. It is expected that the new plant will be in production during the third quarter of 1957.

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STATE LORRIES AND COMPETITION

The Government's decision that the British Transport Commission are to keep the road-haulage trunk services and operate them through the British Road Services establishes a significant precedent. A section of a nationalised industry is to be put up against the competition of private enterprise.

It will be recalled that under the Transport Act 1953 the Disposals Board, which was required to sell the nationalised road-haulage industry back to private enterprise, was given the directive to encourage small men to return to the industry. The Board decided that to meet this requirement some 15,000 lorries should be offered for sale in small lots. In the event these lots were disposed of, and in addition about 1,000 (consisting to a large extent of special vehicles) are being sold, 4,000 are being placed in a parcel service to be run by a new company which is already formed, and 2,000 have been put in the contract-hire category. This accounts altogether for about 22,000 vehicles, and leaves about 8,000 vehicles to be run by B.R.S. as a trunk system. This B.R.S. fleet will be operating in competition with small hauliers. The decision to retain B.R.S. as part of the Transport Com-

mission is thus to be commended as a means of preventing the dispersal of an already existing and efficient trunk service while subjecting that service to continued competition from private enterprise. The Transport Commission will benefit, of course, as well, since they retain a substantial interest in road transport without having a monopoly of it.

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EXPANSION IN SPECIAL STEEL

Samuel Fox and Company, Limited (branch of the United Steel Companies) have announced that they are to build a new bar and rod mill to supply high-quality steels for the ball bearing, motor car and tractor industries, as reported in this issue. This is a major step forward in recognition by the steel industry of the validity of the motor manufacturers' estimates of increased car and tractor sales on which they have based their own vast expansion plans. The new plant, which is to cost £2½ million, is to be a highly-mechanised combination mill, together with a special bar heat-treatment plant. It is designed for maximum flexibility and is expected to reduce considerably re-rolling defects such as seams, laps and decarburisation that may occur in present-day practice. Rolling speeds, it is claimed, will be higher than in any comparable mill at present operating in this country.

Last November, Samuel Fox commissioned a 60-ton electric arc furnace—thought to be the largest in Europe—which, together with a new raw materials stockyard, entailed an outlay of almost £2 million. These steps towards modernising special steel output in Britain are most encouraging, since they should materially assist the engineering industry to improve its competitive position overseas—a need so vital and pressing that it cannot be re-iterated too often. Modern labour-saving plant, widely installed and fully utilised, could go far to save this country from a major balance-of-payments crisis. And if armament programmes are cut further as the cold war gives way to economic co-operation between East and West, export industries such as the motor industry will need all possible support from their suppliers if they are to make up for reduced armament purchases by the United States.

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CAPITAL PROGRAMME CUTS

Official recognition has now been given to the fact that this country's economy (and the engineering industry in particular) cannot carry out all the ambitious programmes for capital development in the immediate future without seriously impairing the export drive or unless home consumption can be reduced. In a statement to the House of Commons on July 25 the Chancellor of the Exchequer made it quite clear that for the time being a further curb will have to be put on all kinds of expenditure in the domestic market in order to maintain the flow of goods abroad. The change in Bank rate in February and the hire-purchase controls reintroduced at the same time have only recently had the chance to affect the supply of credit for industry, but the continued upward pressure on costs and the recent rail and dock strikes have decided the Chancellor to implement his February measures. In this way it is hoped to sustain the export drive and restore confidence in sterling abroad, where it has recently been subject to pressure from speculators.

Expenditure is to be curtailed both in working capital and in long-term capital. The Government are going to reduce their overseas expenditure and also certain domestic outlay. At home, since housing is not to be touched, the first casualty is likely to be the road programme. Local authorities are being asked to hold back their schemes for capital expenditure and the nationalised industries will be called upon to postpone or slow down those schemes which are not already in hand or where it would not cause obvious irreparable dislocation to delay them. Essential objectives in coal production and nuclear power are not to be touched.

High-purchase restrictions are increased in the form of a minimum deposit of 33⅓ per cent. on hire-purchase contracts compared with the previous level of 15 per cent. The most important categories likely to be affected are motor cars and motor cycles, radio and television sets, gramophones, cameras and domestic appliances. Thus, sections of the motor vehicle and light domestic industries which cannot switch to export markets are likely to feel the brunt of these changes. Altogether the prescription is for a mild dose of deflation now to keep export prices down and quantities up, so avoiding more dire medicine later on.

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BRIEFLY SUCCESSFUL

Sir Harry Railing, chairman of the General Electric Company, Limited, made one of the shortest statements to shareholders on record for a company of this size. Yet in it are contained four statements of vital importance to manufacturing concerns, and to the nation. (1) Trading profit for the year ended last March was £1·6 million higher than in the previous year, at £9·9 million. This was achieved " in spite of increased wage costs which we have been unable to recover fully in our selling prices " and, according to Sir Harry, due to increased turnover and to greater efficiencies arising from plant modernisation. (2) Increased turnover was achieved with only a slight increase in stock and work in progress. Many companies would benefit by paying close attention to these items. (3) Exports were lower than the record figure established for the previous year. Sir Harry points out that " expansion in overseas markets becomes increasingly difficult in view of keen competition, import restrictions and local manufacture." In this lies the most serious warning industry could receive. Without such an expansion engineering output is likely to be reduced within the next 12 months. (4) The position with regard to certain consumer goods at home has since become less favourable owing to the measures taken by the Government to curb internal spending. In this lies a possible way to avoid a balance-of-payments crisis, though such financial action as has been taken so far is essentially negative. There is little doubt that expenditure on some consumer durable goods will be reduced by it, but goods of the same type are exported and a reduction of output through lower home sales may in fact raise costs —and export prices—in a way that could make this important section of our industry less rather than more competitive in overseas markets.

G.E.C. is a company whose fortunes reflect those of both heavy and light engineering. What has been achieved owing to plant modernisation can be achieved by others, but the Government's financial squeeze indiscriminately operates against the purchase of modern machine tools as well as that of washing machines. Sooner or later the Government must grasp the nettle of the situation now arising and exert a more selective influence on industry.

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PAYING FOR ROADS

In spite of the enormous difference between the area of Canada and the United Kingdom, some of their road statistics have a striking similarity. In 1955 the number of road vehicles in Great Britain is likely to be about 6 million, running on a rural road system of about 187,000 miles; in Canada the number of vehicles for this year is likely to be about 4 million running on about 180,000 miles of rural surfaced roads. In both countries there is the common problem of the rapid increase in the total vehicle population, including a rapid rise in the numbers of goods vehicles on the roads. Both countries are faced with the problem of how best to finance the construction of a road system which will accommodate the rapidly-increasing vehicle population. A study of this question has been recently published by the Canadian Tax Foundation called " Taxes and Traffic."

Four methods of approach are suggested, the first of these being a comprehensive study into Canada's need for highways, roads and streets over a long period. These studies should be conducted in such a way as to ascertain on whom the financial burden for road development should fall, that is to say, how far it should be borne by users (the various classes of commercial users being separately identified and assessed), how far by owners of property to whom the roads will give access, and how far by the general taxpayer. The authors of the report emphasise the importance of working out the comparative responsibility of local authorities and central government, bearing in mind that one of the most simple ways of collecting dues for a road system is by petrol taxation, which is the monopoly of the central government, while a considerable responsibility for maintaining roads with a high density of traffic falls upon municipalities.

A good deal is said about the advantages and disadvantages of toll roads, which have been the subject of argument in this country as a means of financing road development. It is pointed out that road tolls have been developed in the United States in the last 14 years to no small extent by states through whose territory a large volume of traffic runs without having to take on petrol and oil. Such traffic gains from a road service across a state towards which it has to make no contribution for up-keep. The toll road system in the United States has been financially successful in a period of high prosperity and rising traffic population because tolls have reduced petrol consumption, wear and tear and accidents. In many cases, however, the capital cost of installing tolls has been exceedingly heavy. In general, toll roads do not, in the view of the report, offer any engineering or traffic control advantage over comparable free roads and are more expensive to construct and to operate. Their use is therefore considered to be justifiable only when the more traditional forms of raising funds are inadequate.

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CLEAN AIR

The Government has published the text of its Clean Air Bill, designed to replace Mr. Nabarro's private member's Bill which was debated and withdrawn last February, and to implement the recommendations of the Beaver Report for a clean air policy. The main provisions of the Bill are set out on page 168 of this issue. The Bill as it stands will create certain problems both for the Government and for industry, but there are also many opportunities of good business.

The main problem is to ensure that adequate stocks of smokeless fuels are available where they are required. A supplementary note issued by the Ministry of Housing and Local Government says that the speed at which supplies of smokeless fuel to replace ordinary coal in domestic grates can be increased will depend not only on the expansion of production but also on the progress made by industry in switching over to oil-burning furnaces.

Opportunities will arise principally for the makers of furnaces designed for smokeless operation, and devices for reducing smoke emission in normal furnaces. New boilers must also be equipped with dust and grit arresting plant. To ensure that the amount of grit emitted is kept below specified levels the Bill requires that certain furnaces shall be fitted with instruments for recording such emission. The provision and fitting of these instruments is the responsibility of industry, and there will be many firms needing advice on and supply of the instruments. Where smoke control areas are established householders can receive grants for changing unsuitable forms of heating and cooking to those emitting no smoke. It would seem that there will be an admirable opportunity for the gas and electricity supply authorities, as well as suppliers of stoves burning smokeless fuel.

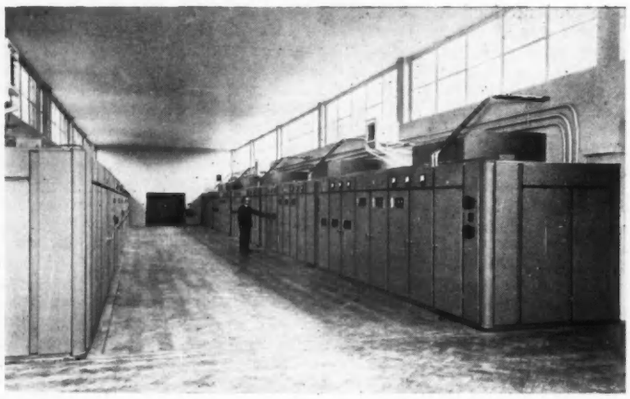

Fig. 1 One of the transmitter halls at the new Rugby radio station. The installation will consist of 28 units.

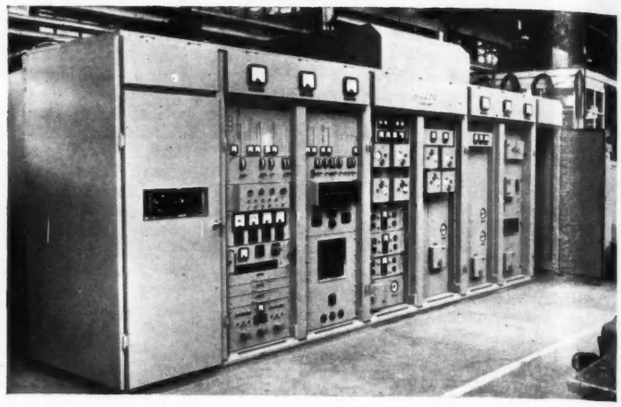

Fig. 2 A 30-kW Marconi transmitter in the works, with the front doors removed to show the controls.

NEW RUGBY RADIO STATION

A DEVELOPMENT IN INTERNATIONAL COMMUNICATION

An important extension to the well-known radio station of the British Post Office at Rugby was formally opened by the Postmaster General, the Rt. Hon. Charles Hill, M.P., on Thursday, July 28. It will eventually consist of 28 high-power transmitters, some of which are already in operation, and, owing to the use of improved equipment, will enable the present traffic-handling capacity to be approximately trebled.

The Rugby radio station was originally opened in 1926* for radio-telegraph transmission on a frequency of 16 kilocycles. Some four years later it was extended by the installation of both telephone and telegraph transmitters operating at between 3 and 30 megacycles on the beam system; and, in spite of additional transmitters having been erected at other stations, it has now become necessary to provide for further expansion.

The site occupied by the new station covers over 700 acres and is large enough to accommodate 100 different types of aerial. The transmitters are housed in three halls, which were designed by the Ministry of Works and consist of steel-framed buildings with hollow-tile flat roofs covered with asphalt. The floors are of reinforced concrete with a wood block finish. Each hall is 114 ft. long by 30 ft. wide and 14 ft. high; they are arranged in the shape of a cross with a central control panel enclosure in the transept formed by their intersection. A view of one of these halls is given in Fig. 1, and the central control position is shown in Fig. 3. In addition, there are ancillary buildings, containing the power and other equipment; and an administration and welfare block. The contractors were Messrs. Foster and Dicksea, Limited, Baker-street, London, W.1.

The signals arriving at the station by land line from London are translated by two types of drive unit which were designed by the Post Office—one for telephony, multi-channel telegraphy and picture transmission, and the second for other types of telegraphy. These units provide an output of two independent side bands, centred on a frequency of 3·1 megacycles, to the transmitters; and each includes a monitoring receiver by which the incoming and outgoing signals are automatically compared. This equipment was constructed by Marconi's Wireless Telegraph Company, Limited, Chelmsford, who were also responsible, in co-operation with the Post Office, for the design and supply of the 30-kW transmitters, the central control system, the aerial selector switching and the feeder arrangements.

TRANSMITTER DESIGN

The transmitters, a view of one of which in the works is given in Fig. 2, accept the low-power signals from the drive units, translate them to a frequency of between 4 and 27·5 megacycles and raise them in level to about 30 kW. A separate radio-frequency crystal drive source is used to generate one of six pre-determined frequencies and electronic keying is used to select continuous wave, frequency-modulated continuous wave and frequency shift-key services. An emergency inductance-capacity oscillator is also available. The tuning of the earlier stages is effected by combined variable inductance and capacity, thus giving complete frequency coverage with one control. Continuous tuning of the power stages over the entire frequency range is possible without any change of components. There is easy access to all parts and performance is improved in the high-power stages by heating the filaments by direct current.

The six harmonic generator and mixer units in the transmitter, to which power is fed at 0·1 watt by coaxial cable, can be pre-set to any frequency and automatically selected. Each consists of two pentode generator stages, a balanced modulator and three radio-frequency amplifiers. The 3·1-megacycle independent side-band drive from the external generator is applied through an attenuator as a push-pull input to the cathodes of the balanced modulator, while the harmonic generator output is applied to the two grids of the modulator in parallel.

For continuous wave or frequency shift-key operation, a 3·1-megacycle signal, provided and keyed or modulated by the external drive and keying unit, is applied as push-pull input to the cathodes of the balanced modulator. The harmonic generator output frequency is applied to the modulator grids in parallel, so that the required radiation frequency is obtained with the modulation appropriate to the particular service.

RADIO-FREQUENCY STAGES

The balanced modulator is followed by a buffer stage, consisting of a pentode operating as an amplifier. The second radio-frequency stage consists of a pentode which is transformer-coupled through two other pentodes in push-pull to the anode circuits, the latter feeding into a balanced 100-ohm line. This line is connected through the drive selector switch to the grids of a pair of tetrode valves in push-pull. The output of the fourth radio-frequency amplifier is supplied through a transformer and capacitance bridge to a pair of tetrodes in parallel. A radio-frequency feed-back voltage from the final anode stage is connected to this bridge in such a way that feed-back voltage is applied to the amplifier grids of the fifth stage, while the radio-frequency amplifier in the preceding, or fourth, stage and the feed-back line are mutually isolated.

The fifth stage amplifier is capacitance coupled to the sixth radio-frequency stage. This consists of a tetrode high-level amplifier which is neutralised to improve the stability at high frequencies. The seventh and eighth stages both comprise earthed-grid amplifiers using air-cooled triodes. The low impedance output of these stages ensures a high order of linearity and thus minimises inter-channel cross-talk. Each of the last three stages comprises continuously-variable inductance and capacitor units which form a whole with the valve mounting. These stages are built as enclosed circuits and are further screened by the main enclosure.

A radio-frequency feed-back is used to reduce distortion, with the result that the form of the signals is accurately preserved. This enables a transmitter to deal with several independent signals simultaneously without interaction. Harmonic radiation is less than 0·2 watt and is

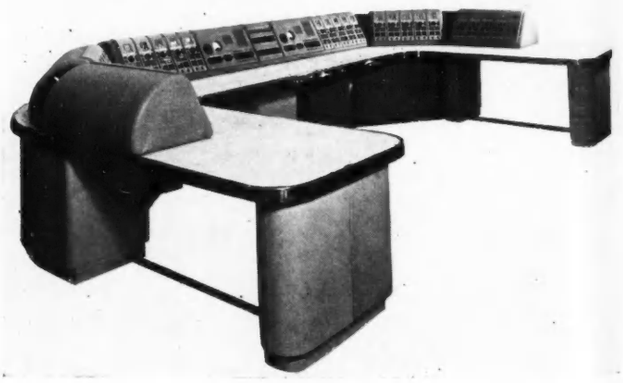

Fig. 3 The central control position from which the transmitters are operated.

* ENGINEERING, vol. 122, page 147, *et seq.* (1926).

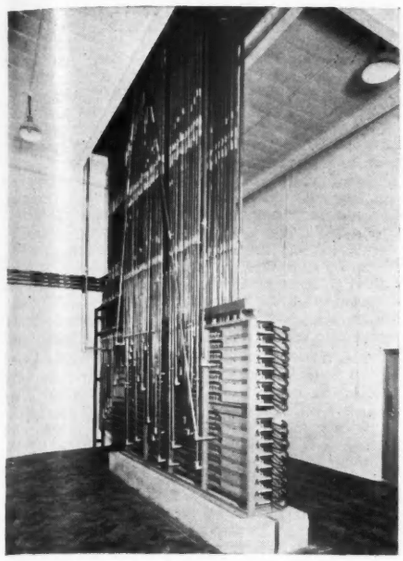

Fig. 4 One of the aerial selector switches which enable 40 aerials and 14 transmitters to be interconnected.

therefore negligible. Air cooling with dust filtering is used throughout. Both unwanted radiation and air noise from the cooling system are kept to a minimum.

It is of interest that the high voltage capacitors used on these transmitters are of the pressurised type, in which the plates are coaxial tubes of copper alloy spaced as little as 1/1,000 in. apart. The position of one set of plates can be varied by a lead screw and the capacitance accordingly altered. The dielectric is sulphahexafluoride, which is maintained at a pressure of 30 lb. per square inch; and the cylindrical container is of Vitreosil with a protective outer layer of polythene. The end plates are of metal with a low coefficient of expansion to minimise the thermal stress. The construction is compact, thus providing a maximum voltage rating for minimum bulk.

CONTROL ARRANGEMENTS

The output of the individual transmitters is led to panels on the control desk, where there are also order wire, inter-communication and monitoring facilities. This desk is so designed that the state of all the radio equipment is indicated and under traffic conditions operational control of the whole station can be carried out by one man, who can start, stop or change the frequency of any transmitter, and also check its operation. Performance is indicated on a mimic diagram.

In order that any aerial may be connected to any transmitter a system of the balanced twin-coaxial type, which can be coupled through a matching section to twin open-wire feeders has been installed. Interchange is effected partly by manual pre-selection of the aerials up to six for each transmitter and thereafter by motor-driven switches which enable any of these aerials to be selected. One of these switches is illustrated in Fig. 4. In addition, special connections are available for temporary changes such as the emergency transfer of a group of aerial feeders to another transmitter. Similarly, if the transmitters and aerials are grouped on more than one switching assembly transfer feeder connections can be arranged between them. Electrical interlocking with the normal transmitter protective circuits is provided. In addition, a low air pressure is maintained in each group of feeders. If any feeder coupling is loosened this pressure is released and the power contactor of the associated transmitter is tripped. The arrangement is such that each of the two groups of selector switches will control up to a maximum of 40 aerials and 14 transmitters.

A single "deck" or level is used for each transmitter. This is connected at one end to the incoming feeders, while up to six twin-coaxial switching units are disposed along its length to correspond with the positions of the outgoing feeders to the aerial. These switching units, together with the make-up sections, form a continuous transmisssion line. The motor drive and selector gear, with the associated control relays and plug connections, are at the other end of the unit. The feeder switches are operated by a chain, which runs the length of the deck and is brought to rest at the required switch by the pre-selector gear.

The transmitter decks are assembled vertically in a framework, as also shown in Fig. 4, and the aerial feeders drop from above in pairs, one on each side of the framework. These feeders can be extended to any deck by telescopic sections, where they are coupled to the switch units. Any deck can be uncoupled and withdrawn from the framework for switch re-grouping or servicing without interfering with the others.

AERIAL DESIGN

Connection from the coaxial path through the switching assembly (the internal diameter of which is 2 in.) is made to the aerials by external feeder runs of 1·5 in. nominal diameter, which are installed on the roof of the buildings and on masts.

The majority of the 58 aerials so far provided, out of the eventual total of 100, are multi-wire rhombics, which, being non-resonant, work over a wide range of frequencies. It has, therefore, been possible to reduce their number thus saving space and simplifying the switching arrangements. There are also four Kooman arrays. The aerials are supported on light lattice masts. These are made up of standard 90 deg. angles with fillets of ½ in. bars, one face being stepped so that they can be climbed.

A supply of power for operating the new plant is obtained from the Area Board's mains through a substation in the old station, which also contains stand-by plant. From this point it is transmitted to two substations on the new site where it is stepped down to 416 volts three-phase, direct-current being obtained from rectifiers. The main contractors for this part of the work were South Wales Switchgear, Limited, Blackwood, Monmouthshire, and the English Electric Company, Limited, Kingsway, London, W.C.2.

ENGINEERING TRADING ON THE NILE

RECOMMENDATIONS TO INDUSTRY AND THE INSTITUTIONS

In the autumn of 1954 a trade mission was sent out to Egypt, the Sudan and Ethiopia to investigate the possibilities of expanding British trade in those territories. The report of the mission, which included among its membership a high proportion of engineers, has now been published as "Report of the United Kingdom Trade Mission to Egypt, The Sudan and Ethiopia." (H.M. Stationery Office, 6*s*.) Circumstances in the three territories differ in some important political respects. Relations with Egypt have been improving since the political détente with that country in 1954; the Sudan is entering upon a period of self-government when contacts with Sudan officials will no longer be automatic because they are British; Ethiopia is enjoying a period of prosperity and looks forward to an ambitious and, it is hoped, co-ordinated development programme. The outlook in all three countries is one of prosperity and growth, coupled with notable emphasis on development projects in which engineering could take part.

So far as Egypt is concerned, the mission points out that the country will remain predominantly agricultural, and even the expansion of agriculture depends upon further irrigation schemes. Special reference is made to the development of the proposed high Aswan Dam, a project with which the mission hopes that British engineering firms will become associated. Extensive track and equipment renewals are necessary on the Egyptian railway system, and improvements to roads, fields, waterways, docks and harbours are also planned as well as extensions to the telecommunication system. Fertilisers and iron and steel are also on the Egyptian Government's list. The mission points out that British engineering consultants and contractors have lost ground in recent years (for reasons of which such firms are only too well aware), and it is suggested that the Association of Consulting Engineers should make known in Egypt the services offered by its members and that the professional institutions should consider giving their members greater freedom to meet foreign competition. The British Electrical and Allied Manufacturers' Association are asked to consider the possibility of adopting the General Conditions for the Supply of Plant and Equipment prepared by the United Nations Economic Commission for Europe. The Institutions of Civil, Mechanical and Electrical Engineers are asked to consider setting up a joint Egyptian branch.

In the Sudan, the rate of development is likely to be slowed down owing to the loss of continuity following the replacement of British officials. Nevertheless, the outlook is considered good for concerns which are prepared to take the trouble to develop local contacts. Capital works in the near future are likely to be concentrated on the railways, although there are indications that roads and electricity will have to have priority in due course. The mission recommends that Sudanese engineers should be brought to the United Kingdom for training in engineering workshops. In Ethiopia the improvement of basic services is likely to proceed, though gradually. Electric power installations, more roads and improved harbour and airfield facilities will be required in due course and are likely to lead to opportunities for British engineering consultants and contractors.

In all three territories, the mission found severe competition from Continental suppliers, a reluctance on the part of some British companies to study local requirements, and room for improvement in advertising and packaging. Broadly, therefore, the outlook is similar to the Middle East outlook generally, but there is no doubt that a willingness on the part of the Egyptian authorities to simplify contracting procedures and accept the need to build up goodwill on their side would make trading on the Nile a much more attractive proposition for British engineering companies and consulting firms.

The members of the mission were: Mr. G. C. R. Eley, C.B.E. (leader), deputy chairman, British Bank of the Middle East; Mr. T. A. L. Paton, M.I.C.E. (deputy leader), partner, Sir Alexander Gibb and Partners; Mr. A. W. Berry, M.I.Mech.E., Director, British Engineers' Association; Mr. A. E. J. Gawler, deputy overseas controller, Imperial Chemical Industries, Limited; Mr. Maurice Laing, managing director, John Laing and Son, Limited; Mr. J. F. Perry, A.M.I.E.E., managing director, Metropolitan-Vickers Electrical Export Company, Limited; Mr. G. Phillips, director, Scales and Adams, Limited, Bradford; Colonel R. E. M. Pratt, O.B.E., British Motor Corporation, Limited; Mr. P. G. G. Salkeld, C.B.E., managing director, Steel Brothers and Company, Limited; Mr. J. C. Tremayne, director, Tootal Broadhurst Lee Company, Limited; and Miss C. B. Reynolds and Mr. D. Steel, of the Board of Trade, respectively secretary and assistant secretary.

PERSONAL

VISCOUNT FALMOUTH has been re-elected President of the British Internal Combustion Engine Research Association, 111-112, Buckingham-avenue, Slough, Buckinghamshire. SIR HAROLD ROXBEE COX, DR. S. F. DOREY and VICE-ADMIRAL SIR FRANK MASON have been re-elected vice-presidents. BRIGADIER H. P. DRAYSON has been elected a vice-president and MR. V. H. HOPKINS and MR. A. C. YEATES have been elected to the Council. MR. J. CALDERWOOD has been elected to be chairman by the Council.

SIR ARNOLD HALL, M.A., F.R.Ae.S., F.R.S., at present director of the Royal Aircraft Establishment, Farnborough, is to join the board of the Hawker Siddeley Group as technical director as from November 1. Sir Arnold's successor at Farnborough is to be MR. G. W. H. GARDNER, C.B., C.B.E., B.Sc., M.I.Mech.E., F.R.Ae.S., at present director general of technical development (air), Ministry of Supply.

SIR CHARLES DRUMMOND ELLIS, B.A., Ph.D., F.R.S., from 1946 until early this year a scientific member of the National Coal Board and a member of the advisory council to the Minister of Fuel and Power, has been appointed scientific adviser to the Gas Council. This is a part-time appointment. Sir Charles has also been appointed a member of the Gas Council's research advisory committee.

SIR JAMES H. BARNES, M.A. (Oxon), K.C.B., K.B.E., until recently permanent Under Secretary of State for Air, has been elected a director of Short Brothers and Harland Ltd.

MR. J. SMITH, M.I.Mech.E., M.I.H. & V.E., has retired as managing director of Edwin Danks & Co. (Oldbury) Ltd., and has been appointed deputy chairman of the company as from July 1. MR. L. W. H. REA, recently made general manager of the firm, has been appointed to the managing directorship.

MR. R. GRESHAM COOKE, C.B.E., M.P., for nine years director of the Society of Motor Manufacturers and Traders, has been elected to the board of Rootes Ltd., the world marketing company for the Rootes Group, Devonshire House, Piccadilly, London, W.1.

MR. PHILIP E. HOLLOWAY has been appointed to the board of directors of the Wellman Smith Owen Engineering Corporation Ltd., Parnell House, Wilton-road, London, S.W.1.

THE SHELL PETROLEUM CO. LTD., announce that all the firm's chemical manufacturing and marketing activities in the United Kingdom and Eire will be concentrated in one company to be called SHELL CHEMICAL CO. LTD. The chairman will be MR. F. A. C. GUÉPIN, the vice-chairman MR. W. F. MITCHELL, the managing director MR. L. H. WILLIAMS and the other directors MR. G. H. W. CULLINAN, MR. E. LE Q. HERBERT, MR. J. W. PLATT, SIR ROBERT ROBINSON, O.M., F.R.S., MR. A. D. KOELEMAN, DR. M. A. MATTHEWS and MR. F. MACKLEY.

The reconstitution of the board of the "SHELL" REFINING AND MARKETING CO. LTD. is also announced. MR. J. W. PLATT will be the new chairman and MR. E. LE Q. HERBERT the managing director. The other directors will be MR. J. A. BERRIMAN, MR. J. GRANT, MR. F. MACKLEY, MR. C. R. MIDDLETON, MR. F. J. STEPHENS, MR. R. W. J. SMITH and MR. W. S. THOMPSON.

MR. C. S. TOSELAND, C.B.E., the Board of Trade and Ministry of Supply Controller for the London and South Eastern Region, is retiring from the public service on September 1. He will be succeeded by MR. BARRY KAY, C.B.E., who is at present Controller of the Midland Region. Mr. Kay will be succeeded at Birmingham by MR. A. N. HALLS, M.B.E., of the London headquarters staff of the Board of Trade.

MR. P. ATTENBOROUGH, MR. G. HOBMAN and MR. E. W. HARDING have been elected to the board of directors of the International Meehanite Metal Co. Ltd., 4 Downside, Epsom, Surrey. MR. E. M. CURRIE, F.I.M., has been made managing director.

MR. N. A. RICHARDSON, B.Sc., A.R.I.C., has been appointed technical adviser to the Association of Tar Distillers, 9 Harley-street, London, W.1. He has been a member of the staff of the Forest Products Research Laboratory since 1929.

MR. JEFFREY WATKINS, B.Sc., A.F.R.Ae.S., formerly of the performance department of D. Napier & Son Ltd., has been appointed senior aerodynamicist to the Solar Aircraft Co., San Diego, California, U.S.A.

MR. M. J. STEPHEN, M.Sc., a graduate of the Witwatersrand University, Johannesburg, has been elected a Salters' Fellow for the year 1955-56 by the Court of the Salters' Company, 36 Portland-place, London, W.1.

MR. L. E. WATTS has been appointed works manager of the Bishop's Stortford Works, Hertfordshire, of Millar's Machinery Co., Ltd., in succession to the late MR. H. J. HUDSON.

MR. F. J. CLAY has been appointed London manager of Goodwin Barsby & Co. Ltd., St. Margaret's Ironworks, Leicester. The address of the London office has now been changed to Morris House, 1-5 Jermyn-street, S.W.1 (Telephone: WHItehall 0527); and that of the Scottish office to 49 Shieldhall-road, Glasgow, S.W.1 (Telephone: Govan 2888).

MR. R. S. J. ANSELL has been appointed sales manager, broach division, B.S.A. Tools Ltd., Redditch.

MR. J. CLEMENT, B.Sc., M.I.E.E., who recently relinquished the managership of the Birmingham office of the British Thomson-Houston Co., Ltd., Rugby, has now been appointed assistant manager, home sales, at the head office, Rugby.

MR. J. M. L. HOWELL has been appointed sales manager (earth moving) to the Distington Engineering Co. Ltd., Workington, Cumberland.

MR. J. L. THORNE has been appointed sales manager to the Fairey Aviation Co. Ltd., Hayes, Middlesex.

MR. RONALD E. DAVIE has been appointed the Scottish sales and service representative for A. A. Jones and Shipman Ltd., Narborough-road South, Leicester. He succeeds MR. M. GOODE, who recently joined the export staff and is at present in Australia. The address of the Scottish service depot of A. A. Jones and Shipman is c/o Messrs. J. H. Barclay & Co. Ltd., 19 Waterloo-street, Glasgow, C.2. (Telephone: Central 6958.)

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COMMERCIAL

BAKELITE LTD., have concluded an agreement with UNION CARBIDE LTD., under which they will market polyethylene plastics produced in the United Kingdom by Union Carbide Ltd. The sales organisation of Bakelite Ltd., will be available for sales of this polyethylene both at home and in export markets.

MATHER & PLATT LTD., Park Works, Manchester, 10, have come to an arrangement with the American firm of packaging-machinery makers, the STANDARD-KNAPP division of the EMHART MANUFACTURING CO., to make their range of packaging equipment in this country. The machinery will be for export as well as for sale in this country.

BRITISH INDUSTRIES FAIR LTD., Ingersoll House, 9, Kingsway, London, W.C.2, announce that an electrical exhibition will be staged in London as part of next year's British Industries Fair. It will be held in the Grand Hall, Olympia, London, W.14, from April 23 until May 4, 1956.

On page 70 of our issue of July 15 we referred to the formation of the CONISTON CO. LTD. We are now informed that the note sent to us was in error and that the title of the company is the CONISTON ENGINEERING CO. LTD., Eagle House, High Street, Wimbledon, S.W.19.

THE POWER PETROLEUM CO. LTD., Cecil Chambers, 76–86, Strand, London, W.C.2, have moved their North Eastern (Leeds) branch office to Bardon Chambers, Infirmary-street, Leeds, 1 (Telephone: Leeds 29366).

HOUSEMAN AND THOMPSON LTD., specialists in industrial water treatment, D.M. House, Jesmond-road, Newcastle-upon-Tyne, 2, have opened a new chemical cleaning factory for industrial machinery at Smeaton Street, Willington Quay, Northumberland.

CANTIE SWITCHES LTD., Port Causeway, New Ferry, Birkenhead, have established new branch offices at 248 West George-street, Glasgow, C.2, under the management of MR. T. C. PATON (Telephone: Central 3739); at 32 Deansgate, Manchester, 3, of which the manager is MR. J. T. JOLLEY (telephone: Blackfriars 3851); at Room 31, Sun Insurance Buildings, Collingwood-street, Newcastle-upon-Tyne, 1, the sales engineer being MR. W. K. FREEMAN (Telephone: Newcastle 29171); and at 37 Talbot-street, Nottingham, in the charge of MR. A. E. ROYLE. Another branch office will shortly be established at Leeds under the management of MR. N. RAYNER.

THE NATIONAL BENZOLE CO. LTD., Wellington House, Buckingham Gate, London, S.W.1, have opened new motor-vehicle workshops at Seacroft, Leeds. The repair and maintenance of the company's fleet of vehicles operating in the North of England will now be centralised here, and the centres previously maintained in Manchester, Sheffield and Stoke have been closed.

CONTRACTS

Low-Pressure Turbine-Generator Set. An order valued at over £285,000 has been received by the METROPOLITAN-VICKERS ELECTRICAL CO. LTD., Trafford Park, Manchester, 17, from the State Electricity Commission of Victoria. It covers a 20-MW 3,000-r.p.m. low-pressure turbine-generator set for installation at the Commission's brown-coal briquetting factory at Morwell. The set will include a double-flow low-pressure turbine designed to use surplus exhaust steam from two Metropolitan-Vickers 30-MW back-pressure turbine-generator sets already installed at the same station. The turbine will be coupled to an air-cooled alternating-current generator designed for a power factor of 0·7. Generation is at 11,000 volts 50 cycles per second. Both the turbine and the generator will be made at the Trafford Park Works.

Radio Apparatus and Equipment. The Gold Coast Posts and Telecommunications Department have placed an order with MARCONI'S WIRELESS TELEGRAPH CO. LTD., Chelmsford, Essex, for the supply and installation of a twin-path, 24-channel (per path), V.H.F. radio communications service from Kumasi to Takoradi, via Mpraeso, Koforidua, Mampong (Akwapim), Accra, Winneba and Cape Coast. The terminal at Takoradi will be accommodated in a new telephone exchange. The equipment to be supplied includes 20 of the firm's multi-channel terminal units and four multi-channel repeater units, together with power supplies, ancillary equipment and spares. A number of channels of each radio path are to be extracted at three points, namely Koforidua, Winneba and Cape Coast, so as to enable local telephone lines in these areas to link with the trunk route. At all repeater stations, the equipment will work entirely unattended. The project will link with a twin-path 12-channel (per path) service between Tamale in the North and Kumasi, the supply and installation of which is already being carried out by Messrs. Marconi.

Plant for Indian Railway Electrification Scheme. An order valued at approximately £300,000 has been placed with the BRITISH THOMSON-HOUSTON EXPORT CO., LTD., Rugby, through A.E.I. (INDIA) LTD., for converting plant, direct-current switchgear, and control gear for the first stage in the main-line electrification scheme of the Eastern Railway of India. The order covers six substations and three track-section cabins on the main line from Calcutta (Howrah) to Burdwan, a distance of 66 miles, and one track cabin at Karmarkundu which is on the branch line to Tarakaswar.

The converting plant consists of eight 2,500-kW and four 3,000-kW 3,000-volt 12-phase pumpless steel-tank mercury-arc rectifier equipments, each including two withdrawable truck-mounted rectifiers, an outdoor transformer and a control cubicle. These are to be installed in two triple-unit, two double-unit and two single-unit substations.

The direct-current switchgear for the rectifiers, track feeders and track sectioning cabins comprises high-speed circuit breakers which, with their associated control gear, are mounted on withdrawable trucks. These will be housed in concrete cells.

The order also includes low-tension switchgear and certain substation auxiliaries.

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OBITUARY

We regret to record the deaths of:

MR. WALTER HENRY COOKE, M.I.E.E., at his home in Luton, Bedfordshire, on July 22, at the age of 85. For nearly 40 years he was connected with the Luton Corporation Electric Supply, which he joined in 1900 as assistant to Mr. Albion T. Snell. He was appointed chief engineer and manager of the undertaking in the following year and retired in 1939. Mr. Cooke was a pioneer in advocating a cheap tariff for domestic heating and cooking purposes.

MR. HENRY BERNARD BAMFORD, on July 22, at the age of 80. He was chairman of Bamfords Ltd., agricultural engineers, Uttoxeter, Staffordshire. Mr. Bamford was the eldest son of Mr. Samuel B. Bamford, one of the founders of the business and had been connected with the firm since 1894. When a limited company was formed in 1916, Mr. H. B. Bamford became one of the first directors.

MR. JAMES CAMERON, of Stamfordham, Northumberland, in hospital in Newcastle-upon-Tyne, on July 27, at the age of 77. For 35 years Mr. Cameron served as secretary of the North-East Coast Engineering Employers' Association, the Tyne Shipbuilders' Association, and the North-East Coast Shiprepairers' Association.

Letters to the Editor

DRAWING AND DESIGN

SIR, It was a change to read the article on engineering design by Mr. Clausen in your issue of June 24. He has put the work of those who design engineering work in its proper perspective. Great works such as the Forth Railway Bridge, the world's largest walking dragline and more recently the new Brunswick Wharf Power Station could not have been executed without first-rate designers.

However, the problem is to see how we can attract more of those boys who leave public and grammar schools into the design office and so gradually raise the standard of personality of those who make design work their profession.

The design department should not be looked upon as the training ground for other departments. Rather should it be regarded as the department on which all others depend, for without design there can be nothing else, and it is precisely the brilliance of many of our designers that has made this country what it is. How many financiers who have never designed anything recognise this?

Yours very truly,
"DESIGNER."

Cheltenham.
July 27, 1955.

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METHODS OF PHOTOGRAPHING AIR FLOW

SIR, It was with interest that I noted a reference to the Schlieren camera in your article on the supersonic wind tunnel (July 1) used for the photographing of shock waves. There is, I believe, another system for photographing air flow around a body at low speeds, using hot wires upstream that are "blipped" electrically to produce small bubbles of warmed air. A special light system is used, presumably utilising the differing refractive index of the air bubbles.

I would be grateful for information on both these systems from any of your readers.

Yours faithfully,
J. LOCKWOOD.

73 Harewood-road,
Westlands Estate,
Chelmsford, Essex.
July 25, 1955.

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DIPLOMAS IN TECHNOLOGY

SIR, I would like to make a comment on the proposals for a scheme of Diplomas in Technology, given in your issue of July 22.

Your editorial comment in that issue concludes that the scheme must be judged in the light of the over-riding necessity for the educational system to turn out men and women with various types of education in the right proportions. Neither your editorial nor the text of the Minister's proposals makes it clear how the new Diplomas will fit into the scheme of technical education, and exactly what type of qualification they will provide.

To say they will be "equivalent to a university degree" is not very helpful. A degree is a known and accepted thing, and no young man who desires to get one and has the ability to reach the standard should be debarred from doing so. If existing facilities for instruction to degree standard are inadequate, it either is or is not possible to increase them, but in neither case is anything achieved by giving a new name to an existing qualification. A different name ought to indicate a different thing. If then, the new diploma is to differ materially from a degree, wherein is the difference to lie? The proposals seem very vague on this point, and one cannot help feeling that the vagueness is, in part at least, deliberate. The intention may be that the diploma will be taken by those who do not possess university entrance requirements. It should be remembered, however, that these entrance requirements are one of the factors that give a degree its value, and their absence is enough to make the diploma less valuable than a degree.

The Minister's proposals speak of "a qualification comparable in value to a university first degree." Unless the similarity and difference are more clearly defined, university graduates are bound to feel suspicious that a lesser qualification is being palmed off on industry as of equal value. National needs cannot make it dishonourable to be jealous lest the high prestige of existing awards be endangered by rash comparison with new and ill-defined awards.

Yours faithfully,
F. PORGES.

28 Alan Moss-road,
Loughborough,
Leicestershire.
July 27, 1955.

SIR, I was interested to see that a chairman had been appointed to the new National Council for Diplomas in Technology, but I could not help wondering how the choice had been made.

I am full of admiration for the new chairman as a driver of an industrial team of technologists; but I should have thought it might have been wiser to select for this post a man who had qualified himself by examination as a result of part-time study at a technical college and had later risen to a high position, rather than one who had risen by his leadership of men and then received an honorary degree. The former would appreciate the danger of sacrificing quality for quantity in the ranks of professional engineers, but he would also know, from his own experience, the special problems of the part-time student at a technical college trying to qualify himself for an engineering degree. In my opinion, no one who has by-passed the part-time degree mill can possibly appreciate the human problems involved in part-time education.

The chairman having been appointed, it is to be hoped that he will be able to enlist the services of at least one engineer of the type I have indicated on his Council.

Your faithfully,
"CHARTERED MECHANICAL ENGINEER."
July 27, 1955.

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THICK-WALLED CYLINDERS UNDER INTERNAL PRESSURE

SIR, We have read the letter by Helmut Leinss commenting on our paper on ultimate pressures. His equation (3) seems a simple equation representing our results, but in fact if his constants had been 1·00 instead of 1·02 and 0·500 instead of 0·456 then this equation would have reduced to $p_{max.} = \frac{2(K-1)}{K+1}\sigma_B$ which is the mean-diameter formula. The mean-diameter formula is, of course, based on the thin-walled formula quoted by Helmut Leinss, and our experimental work shows that it agrees very well with our results. It would be very interesting to know if this equation applies equally well to all ductile materials, and the authors are at present engaged in testing two other materials with this point in mind.

Regarding the last part of the letter, the argument put forward, which appeared to verify an assumption that the axial stress is not uniform across the section, is invalidated by incorrect values taken for the yield points from Fig. 18 in the original article. The axial strain at the outside diameter is particularly insensitive to yield at the bore, especially for large values of K, and the yield could not be determined with any degree certainty of from these curves. The authors would refer the writer to a paper by Professor J. L. M. Morrison, D.Sc., M.I.Mech.E., "Criterion of 'Yield' of Gun Steels" (*Proc. I.Mech.E.*, vol. 159, page 81, 1948), in which it was shown that the Mises-Hencky criterion fitted the experimental results he obtained with a remarkable degree of consistency. During our tests we did note that the yield shown by the diametral strains agreed fairly well with that predicted by the Mises-Hencky criterion.

Yours faithfully,
B. CROSSLAND,
J. A. BONES.

University of Bristol.
University Engineering Laboratories,
University-walk,
Bristol, 8.
July 29, 1955.

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WHITWORTH FELLOWSHIPS

Scholarships Abandoned

When Joseph Whitworth, in 1868, entered into a Deed of Covenant and Trust with the Duke of Marlborough, at that time President of the Council of Education, his purpose, by means of the scholarships which were established under the Trust, was that "the artisan should be encouraged to study theory." In as far as Whitworth's intentions can be expressed in terms of present-day conditions, they were that apprentices receiving their technical education in evening or day-release classes should be enabled to pursue their studies at a more advanced level. The Deed of Covenant containing a clause to the effect that the conditions of award may be varied "in accordance with the progress of human knowledge," and considerable advantage has been taken of this permission in the course of the 87 years in which the Trust has been in operation.

There is no doubt whatever but that Whitworth's original idea was that young men engaged in practical industry should be given an opportunity to obtain theoretical instruction and it was made a condition that candidates should have worked for two consecutive years in "a mechanical engineer's shop." In general, the requirement that workshop experience was a prior condition for an award has been retained in the many modifications which have been made in the requirements over the years. In 1948, however, the Ministry of Education, which now administers the Trust, introduced Senior Scholarships which could be held by graduates or those with Higher National Diplomas or Higher National Certificates in Mechanical Engineering, but whose careers did not include the workshop experience which had always been a prior condition for an award. To make good this lack of practical training, holders of the scholarships were required to enter an engineering works for a period of at least 12 months.

What may be described as the diversion of the Whitworth fund from the shop apprentice to the student has now been carried out in full. In 1948 and the years following, in addition to Senior Scholarships open to graduates, there were also five Whitworth Scholarships available to candidates who were not full-time students. From 1956, however, Whitworth Fellowships, each worth £500 a year and normally tenable for two years, will be introduced and Whitworth Scholarships have been abandoned. Fellowships will be awarded only to graduates or those with corresponding qualifications; the shop apprentice for whom Joseph Whitworth originally catered has been eliminated. The value of practical training has, however, been recognised, as candidates for Fellowships are required to have had works training of at least 104 weeks. Drawing office experience up to a maximum of 6 months may be included as part of the period of practical training, candidates for Fellowships may enter their names in the final year of their

academic course, an award naturally depending on its satisfactory conclusion.

There is ample justification for this fundamental re-orientation of Whitworth's fund. In his day, the shop apprentice had little or no opportunity to reinforce his practical experience with theoretical studies. Nowadays, with the great increase in the number of maintenance allowances and scholarships from public funds, and the educational facilities available to shop apprentices, any youth with the necessary ability can arrange to proceed to a university. This has had a marked effect on the entry for Whitworth Scholarship examinations. Most youths take the easier path of applying for one of the numerous local or other scholarships which are available. At the same time, the need for post-graduate awards has increased owing to the insistent demand for highly trained technologists in almost all branches of industry. It may be surmised that Joseph Whitworth would have admitted that "the progress of human knowledge" has justified this cardinal modification of his original scholarship scheme.

* * *

ROYAL CHARTER FOR MANCHESTER COLLEGE OF TECHNOLOGY

A Royal Charter is to be granted to the Manchester College of Technology. The College began as a mechanics institute in 1827; the Manchester Corporation assumed control in 1889 and the present building was opened in 1902. When the Royal Charter creating the Victoria University was granted in 1903, the faculty of technology was established at the college.

As an independent institution it will continue to provide advanced technological training for both university and non-university students, and will still contain the University's faculty of technology. Building development plans are expected to be announced soon.

* * *

AMERICAN ENGINEERING SOCIETIES' MEETINGS

A meeting of the Society of Automotive Engineers is being held at Milwaukee, Wisconsin, United States, from September 12 to 15 next, to mark the institution's Golden Jubilee. Papers to be presented will deal principally with the design and development of modern tractors and with production problems generally,

The 75th anniversary meeting of the American Society of Mechanical Engineers will take place in Chicago, Illinois, from Sunday, November 13, to Friday, November 18, 1955. The headquarters of both the institutions are at 29 West 39th-street, New York 18, U.S.A.

* * *

SWING-SHOVEL TRENCHER

It is now possible to fit the Ahlmann hydraulically-operated swing-shovel, described in our issue of September 24, 1954, page 409, with trenching equipment. The largest bucket which can be fitted has a capacity of 10 cub. ft., can dig trenches as deep as 5 ft. 6 in., and has a lifting height of approximately 6 ft. The agents in the United Kingdom are Abelson and Company (Engineers), Limited, Coventry-road, Sheldon, Birmingham, 26.

* * *

APPRENTICESHIP AT TRAFFORD PARK

In the penultimate paragraph of the article on this subject in our issue of July 22 (page 100) it should have been stated that 33 per cent. of university students read scientific and technological subjects, of whom 21 per cent. are studying pure science and 12 per cent. technology.

THE CLEAN AIR BILL

ESTABLISHMENT OF SMOKE CONTROL AREAS

The four main purposes of the Government's Clean Air Bill, the text of which was published on July 27, are: to prohibit the emission of dark smoke from chimneys, railway engines, and vessels, subject to certain qualifications; to prohibit the installation of new industrial furnaces unless they are capable, so far as practicable, of being operated without emitting smoke; to require that the emission of dust and grit from existing furnaces shall be minimised, and that new furnaces shall have grit-arresting equipment; and to empower local authorities to declare "smoke control" areas in which the emission of smoke will be an offence.

This Bill is the result of the Government's promise to Mr. Gerald Nabarro, M.P. for Kidderminster, to replace his Clean Air Bill, which was debated last February, by a more comprehensive measure. Mr. Nabarro's Bill suffered from the disadvantage that no financial clauses could be introduced because it was a private member's Bill. In the opinion of the Minister of Housing and Local Government, Mr. Duncan Sandys, in the debate on February 4, Mr. Nabarro's Bill was defective in certain respects, and more time was needed for consultation. He said: "If the new Bill is to be intelligible, practicable and reasonable, it must, we consider, be framed in close consultaton with those who will be most directly affected. In particular, we consider that we must have full consultations with local authorities, with industry, both employers and trade unions, and with various technical bodies whose advice we need."

In view of the number of people consulted by the Government it is not surprising that there are several differences between Mr. Nabarro's and the Government's Bill; nevertheless, the Bill put forward by the Government seeks to implement, as did that put forward by Mr. Nabarro, the recommendations for a clean air policy made by the Beaver report. (The Beaver report was summarised in ENGINEERING for December 3, 1954, vol. 178, page 718, and editorial comment appeared on page 715 of the same issue.)

PROHIBITION OF DARK SMOKE, AND EXEMPTIONS

The Bill prohibits the emission of dark smoke from the chimney of any building, and subject to certain provisions anyone who allows or causes dark smoke to be emitted is guilty of an offence. This does not apply to emissions of smoke for a period shorter than that which may be specified by the Minister. Dark smoke is defined as smoke which is as dark as shade 2 on the Ringelmann chart. In any proceedings for an offence under this section it would be sufficient defence to prove that the smoke was due to: (*a*) lighting up the furnace from cold; or (*b*) the failure of a furnace or some part of it that could not reasonably have been foreseen; or (*c*) the use of unsuitable fuel, suitable fuel being unobtainable and the most suitable available fuel having been used. Until seven years after the appointed day it would also be a defence to prove that (*a*) the smoke was due to the nature of the building and its equipment; and (*b*) that it had not been practicable to alter or equip the building so that dark smoke should not be emitted. After the seven years were up it would also be possible for local authorities to issue certificates to acknowledge that it had still not been possible to alter or equip the building satisfactorily. These certificates could be issued for periods of one year or less and could apply to individual chimneys.

In the sections concerning the emission of smoke, dust and grit from furnaces, the provisions do not apply to furnaces designed solely or mainly for domestic use. No new furnace shall be installed in a building unless it can be continuously operated without emitting smoke; this provision does not apply to a furnace the installation of which has begun, or an agreement for the purchase or installation of which has been entered into, before the appointed day. The occupier of any building in which a furnace is used to burn solid fuel must take all steps to see that the emission of dust and grit is reduced to a minimum. Furnaces burning pulverised fuel, or, at a rate of ten tons an hour or more, solid fuel in any other form, must have grit and dust arresting plant approved by the local authority. The local authority may also require owners of furnaces to make measurements of dust and grit emitted and to furnish details of the measurements and other information regarding the furnace, as for example the type of fuel burnt.

SMOKE CONTROL AREAS

Local authorities may establish smoke control areas, but the orders must be confirmed by the Minister. In a smoke control area it is an offence to emit smoke, but it is sufficient defence to prove that authorised fuel is being burnt. The order establishing a smoke control area can make different provisions for different parts of the area, or can limit the order to certain classes of building, or may exempt certain buildings or types of fireplace within the area.

Between the confirmation of an order for a smoke control area and its coming into operation, owners or occupiers of private dwellings within the area are to receive grants for the conversion of their existing equipment into a condition for satisfactory smokeless operation. The types of work that are admissible as conversion or adaption for the purpose of receiving a grant are: (*a*) adapting or converting any fireplace; (*b*) replacing any fireplace by another fireplace or by some other means of heating or cooking; (*c*) altering any flue or chimney which serves any fireplace; (*d*) carrying out any operation incidental to (*a*), (*b*), or (*c*).

The grants towards the cost of adapting or replacing grates and stoves will cover not less than 70 per cent. of approved expenditure, and at the discretion of the local authority may cover more. The exchequer will pay 40 per cent. of such expenditure and the local authority the remainder.

Certain other cases are covered by the Bill. Owners of colliery spoilbanks are to take all practicable steps to minimise the emission of smoke and fumes. Locomotives and vessels in inland waters are prohibited from emitting dark smoke, and locomotives are also required to adopt all practicable means to minimise the emission of other smoke. In the case of industrial processes where the prevention of smoke, grit and dust present special technical difficulties, the duty of supervision will be entrusted to the Government Alkali Inspectorate, instead of the local authority. For this purpose the Bill extends the operation of the Alkali Act, 1906, to cover smoke, grit and dust. It will be necessary to add to the list of industrial processes to which the Alkali Act at present applies. This can be done by Order under existing statutory powers.

The general duty of enforcing the provisions of the Bill is placed on the local authorities, excluding those buildings which come under the Alkali Inspectorate. The maximum fine for industrial offences is £100 and for domestic offences £10. The Minister is empowered to appoint the date or dates on which the provisions of the Bill come into force, and may appoint different dates for different provisions. In the financial memorandum prefacing the Bill it is stated that the costs to the Exchequer of grants in respect of grates, stoves, etc., is not expected to exceed £3 million per year. The cost of additional technical staff to assist local authorities is not expected to exceed £40,000 per year.

BRITISH STANDARDS

The following publications have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 2 Park-street, London, W.1, at the price given after each title.

Aluminium Wire for Electrical Purposes. (2*s.* 6*d.*, post free.)

A new specification, B.S.2627, entitled "Wrought Aluminium for Electrical Purposes—Wire," has now been published. It has been prepared at the request of the Aluminium Development Association and refers to wire used for electrical conductors such as overhead transmission lines, insulated cables, or windings for rotating machinery or transformers. The standard is suitable for controlling the quality of wire supplied for electrical components made to other British Standards, such as B.S.215, covering hard-drawn aluminium and steel-cored aluminium conductors, and B.S.E21, which relates to electric cables for aircraft.

Horizontal Mild-Steel Welded Storage Tanks. (4*s.*, post free.)

Another new Standard, B.S.2594, relates to the design and construction of mild-steel fusion-welded horizontal storage tanks with dished and flanged ends complying with Table 4 of B.S.1966, which deals with domed ends for tanks and pressure vessels. Tanks with unflanged outwardly-dished ends are also covered by the new specification. The sizes of tanks range from 3 ft. 6 in. in diameter by 4 ft. nominal length up to 9 ft. in diameter by 30 ft. nominal length. The tanks are intended for the static storage of liquids which are not corrosive to mild steel. They are classified by dimensions instead of by capacities, which has been the practice in the trade hitherto. As a guide to users, however, the gross capacities of the tanks are given in the tables. Tanks with flat ends or with inwardly-dished ends are not provided for in the new Standard nor does it relate to tanks on transport vehicles or to lined tanks.

Steam-Turbine Oils. (7*s.* 6*d.*, post free.)

A completely revised edition of B.S.489, first published in 1933 under the title "Turbine Oils," and specifying requirements for straight hydro-carbon oils without additives, has now been issued. As required by modern practice, the new publication covers oils containing additives, and viscosity is expressed in centistokes at 100 deg. F. and 210 deg. F. in order to conform to present usage. The grade of each oil is defined by the viscosity range at 100 deg. F., and the standard covers four grades of lubricating oils for steam turbines, namely, light, medium, heavy and extra heavy.

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TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Fork-lift Trucks. RANSOMES, SIMS AND JEFFERIES LTD., Ipswich. Fork-lift trucks with capacities of 10, 20 and 40 cwt., battery driven, with standard free lift of 4 in. or high free lift (before overall height increases) of up to 5 ft. 1 in. Maximum lifts up to 10 ft. Also accessories: crane attachment, bar attachment, load clamp, side-shift mechanism, load guards, etc. Illustrated descriptive catalogue.

Indicators, Recorders and Controllers. GEORGE KENT LTD., Luton, Bedfordshire. Meters for indicating, recording and controlling such items as oxygen supply, air or gas flows, Wobbe index, pressures and temperatures. A series of leaflets covering the different applications.

Electric Trucks and Cranes. RANSOMES, SIMS AND JEFFERIES LTD., Ipswich. Platform trucks, cranes and tractors, fixed or elevating platforms. Trucks up to 4-ton capacity; tractors to haul 10 tons. All battery-driven models. Illustrated descriptive catalogue.

Domestic Heating. HURSEAL LTD., 229 Regent-street, London, W.1. Oil-filled safety radiators, fixed or portable; "Hurdapta" open convector fire, details and fitting instructions; mineral wool lagging, lengths, shapes and loose material. Three leaflets.

Twisting Wire. DOUGLAS CANE ASSOCIATES, 55 Pall Mall, London, S.W.1. Robinson wire-twisting tool for twisting locking wires, etc. Wire is gripped in jaws, similar to pliers, and then clamped. Pulling a central spindle causes jaws to rotate and so twists the wire. Three sizes made. Leaflet.

BOOK REVIEWS

The Railway Engineers. By O. S. NOCK. *B. T. Batsford, Limited, 4 Fitzhardinge-street, London, W.1.* (18*s.*)

The great social, economic and industrial changes characteristic of the Nineteenth Century were intimately bound up with the rise of railed transport, which became possible once the steam locomotive had been developed sufficiently to allow of heavy loads being hauled over appreciable distances at speeds much in excess of anything practicable on the highway. This was proved conclusively by the success of the Liverpool and Manchester Railway, opened in 1830, and within a comparatively few years railways had spread to most parts of the United Kingdom and been introduced into other lands. Within half a century all the essential elements of sound railway operation were known and it remained to perfect the details, a process still going on.

Mr. Nock's latest book recounts the story of the achievements of men such as Trevithick, Hackworth, the Stephensons, Locke, Cubitt, Vignoles and Brunel, to name but a few who, with very little to guide them, overcame so many difficulties. Their courage was equalled by the enterprise of those who had confidence in their abilities and were ready to find the material means essential to their success. Mr. Nock, well known for his other works on railways and especially on locomotive running, has brought together in moderate compass the essence of information contained in earlier publications, some now forgotten and most of them out of print, and he has retold, with much interesting anecdote and numerous and pleasing illustrations taken from old prints, the romance of the creation of the railway system. He presents it in such a way that the successes achieved and the disappointments encountered come vividly to the mind, as well as the characters of the men concerned in them and the conditions under which they laboured. It is not surprising that many of these men lived hardly beyond middle life, for they wore themselves out with incessant work, often to the accompaniment of great anxieties.

The versatility of some of them was remarkable, as was their occasional advocacy of methods inherently unsound, such as Brunel's extraordinary championing of the atmospheric railway—something which would have encountered insuperable obstacles directly junctions and large stations came to be considered. It is pleasing to read how, although often in rivalry and standing for opposite opinions on some vital matter, men like Brunel and Robert Stephenson would help each other, as in the case of the Britannia tubular bridge, displaying a true greatness of heart and contempt of all meanness. Though it is of the civil and then the locomotive engineers that one thinks mostly in connection with this subject—for the former must make the lines before the latter can do anything effectual—nevertheless, as Mr. Nock emphasises in his chapter on running the trains, the telegraph engineers also played a great part in the story, while brakes and signals demanded a care not always accorded to them. His book shows what an extraordinary attitude was adopted by some railway administrators, in the face of recommendations of Government officers and the lessons of numerous accidents, towards the introduction of essential improvements in these respects. It needed a very serious accident indeed before Parliament could be induced to make continuous automatic brakes obligatory on passenger trains and to insist on the space interval on all passenger lines. The Act which imposed these did not, however, as Mr. Nock thinks, prescribe any particular practice in working the block system; it simply required it to be used, thereby positively excluding the time-interval system, and left it to the railways to work it in whatever manner they thought fit. The work of Newcomen, Watt and others in connection with the introduction of the stationary engine, from which steam-boat and locomotive engines naturally developed, also receives notice. The book will appeal not only to those for whom the railway, despite the rise of competing methods of transport, retains its peculiar fascination, but to anyone who enjoys reading the history of the arts and sciences.

Commercial and Technical Libraries. By J. P. LAMB. Library Association Series of Library Manuals, No. 10. *George Allen and Unwin, Limited, 40 Museum-street, London, W.C.1.* (21*s.*)

As City Librarian, Sheffield, Mr. Lamb writes with authority on the subject with which this book is concerned. The Science and Commerce Library of that city was not the first of its type to be established; Glasgow was the pioneer, its Commercial Library being established in 1916, and its example was followed by Liverpool a year later. The Sheffield library has, however, established an enviable reputation for the service it renders to the industries of the city and surrounding district. The extent of that service is gratefully acknowledged by Sir Walter Benton Jones, the chairman of the United Steel Companies, in a preface to the book. His statement that the library "answers thousands of inquiries of a highly specialist character" from its own resources, indicates that it is not only a library; it is an information department.

Mr. Lamb's first chapter covers an interesting survey of the history of the development of commercial and technical departments in public libraries. The idea that such departments should be provided in general public libraries received little encouragement from outside authorities and most towns had no funds directly available for their establishment. The Library Association interested itself in the matter and when the research associations were formed under the auspices of the Department of Scientific and Industrial Research, the idea that the technical libraries which they built up should be reserved for the use of members was strongly opposed; such libraries were partly supported by public funds. A report of the Adult Education Committee of the Ministry of Reconstruction, in 1919, stated that "in the case of general libraries the unit of organisation and administration is the local authority; in the case of the technical library system it should be the industry."

As the prosperity of most local authorities depends on local industries it is fitting that library services should be provided to serve them. The formation of a commercial department in a public library is probably a more simple matter than the formation of a technical one. The provision of directories, trade reports and similar material will be of service to a wide range of commercial interests but many technical industries require highly specialist material. This cannot reasonably be stocked by a public library, but as Mr. Lamb shows, such a library can stock many useful books and periodicals. Industry is best served by the co-operation between public and specialist libraries which is now fairly common and which has been encouraged and promoted by the activities of Aslib—activities which have had the effect, over many years, of bringing public and specialist libraries and information officers into intimate contact.

Mr. Lamb describes the organisation and layout of the commercial and technical departments of a number of important public libraries. He deals in an informative way with the selection and management of staff, and, in considerable detail, with desirable book and periodical stocks. In general, he provides a complete guide to the organisation and administration of the special public library departments with which he is concerned. At the end of his book he makes reference to the proposed National Reference Library of Science and Technology. This, in common with the Patent Office Library and the Science Library, would be situated in London, but, as he remarks, elsewhere the public library will probably remain the only easily accessible source of literature serving industry.

THE INSTITUTE OF METALS

Buxton Autumn Meeting

The forty-seventh annual autumn meeting of the Institute of Metals, 4 Grosvenor-gardens, London, S.W.1, will be held at Buxton, Derbyshire, from Monday to Friday, September 19 to 23. Meetings for the discussion of papers will take place at the Palace Hotel, Buxton.

On the afternoon of the first day two simultaneous scientific sessions will be held, commencing at 3. The theme of the discussion at session "A" will be "Transformations in Copper Alloys" and the two themes of session "B", "Corrosion of Aluminium Alloys" and "Deformation and Creep of Aluminium Alloys." In the evening, at 8, a civic reception will be held at the Palace Hotel.

On Tuesday, September 20, the members will leave Buxton so as to reach the University of Sheffield, Western Bank, Sheffield, 10, at 10.30 a.m., to hear the 26th Autumn Lecture of the Institute on "The Development and Improvement of Research Techniques," by Dr. C. Sykes, F.R.S.

After luncheon, steel and other works in Sheffield and Chesterfield will be visited.

On Wednesday, September 21, all-day visits will be paid to works in Staffordshire and at Sheffield and Rotherham.

On Thursday morning, September 22, at 9.15, an extraordinary general meeting will be held, after which, at 9.45, two simultaneous scientific sessions will again take place, the theme of session "A" being "Working Properties of Metals," and that of session "B," "Radiation Damage to Metals, and Associated Problems."

In the afternoon there will be visits to works in Sheffield, Matlock and other localities, and in the evening a banquet will be held in the Palace Hotel.

The final day of the meeting, Friday, Septemper 23, will be devoted to an all-day coach tour of Derbyshire.

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THE IRON AND STEEL INSTITUTE

Scunthorpe Meeting

The Council of the Iron and Steel Institute have accepted an invitation from the Lincolnshire Iron and Steel Institute to hold a special meeting in Scunthorpe from Wednesday to Friday, October 12 to 14.

Two morning technical sessions will be held, the one on Wednesday, October 12, and the other on Thursday, October 13, both commencing at 10 a.m. On Wednesday, papers relating to ironmaking at Appleby-Frodingham and extensions at the Lysaght Scunthorpe Works will be discussed. On Thursday, October 13, two simultaneous technical sessions will be held, session "A" dealing with "Steelmaking at Redbourn" and "Organisation for maintenance" and session "B" with the "Dragonby Ironstone Mine" and "The Treatment of Low-Grade Ores at Appleby-Frodingham."

On the afternoons of Wednesday and Thursday, October 12 and 13, and on Friday morning, October 14, visits will be paid to the plants of the Appleby-Frodingham Steel Company, John Lysaght's Scunthorpe Works Limited and Richard Thomas and Baldwins Limited, at Redbourn, the steel foundry of Thos. Firth and John Brown Limited, and the Dragonby Ironstone Mine of the United Steel Companies Limited.

A reception will be held at the Baths Hall, Scunthorpe, by invitation of the Mayor and Corporation of Scunthorpe on the evening of October 12, and on the following evening a dinner will be held by invitation of the Lincolnshire Iron and Steel Institute, at Elsham Hall.

BOOKS RECEIVED

Some of the books noticed here are selected for extended review in ENGINEERING.

Coal-Burning Space Heaters. Case Study Data on Productivity and Factory Performance. Prepared for the Foreign Operations Administration, Office of Industrial Resources, by the United States Department of Labor. Distributed in Great Britain by the *British Institute of Management*, 8 *Hill-street, London, W.*1. (7*s.* 6*d.*)

This report is an analysis of methods of making coal-burning space heaters with details of materials, production techniques, performance of workers, work flow, and a number of case studies; it is written for manager and production engineers.

Questions and Answers on Surveying and Levelling. By R. H. GOULD. *George Newnes, Limited, Tower House, Southampton-street, London, W.C.*2. (6*s.*)

This is the thirty-second volume of the "Question-and-Answer" series. It has been written with the object of applying theory to examples encountered in the field. The various instruments employed are described, together with the methods of checking them and their mode of use. Examples of the trigonometry involved are also given.

Elementary Plane Surveying. By RAYMOND E. DAVIS. Third edition. *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (5·50 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (41*s.* 6*d.*)

This is an introductory textbook of surveying containing, however, chapters of value to the young engineer after he leaves college and commences work in the office and field. Fundamental principles of the subject are stated and the use and care of instruments are described. The techniques available for measuring and plotting angles and distances, and the problems of making complete surveys, are fully discussed. Theoretical aspects of the subject are stressed but the text aims to develop a sense of proportion in respect of precision of measurement. Some differences in American terms and practices should be noted by British readers.

A Glossary of Sanitary-Engineering Terms. Compiled by PETER C. G. ISAAC. Bulletin No. 4, Department of Civil Engineering, King's College, University of Durham. *Public Health Engineering Laboratory, Kings College, Newcastle-upon-Tyne.* (5*s.*)

This glossary of terms used in sanitary engineering has been prepared in co-operation with the World Health Organisation, and was originally intended to be the English contribution to a multi-lingual dictionary on the subject. The terms given—they are described rather than defined—are applicable to a wider field than might be judged from the title and the addition of various appendices makes it a useful reference book for the municipal engineering department.

Panama. Overseas Economic Survey. By E. A. CLEUGH. Published for the Board of Trade, Commercial Relations and Exports Department, by *H.M. Stationery Office, Kingsway, London, W.C.*2. (1*s.* 6*d.*)

In this survey of economic and commercial conditions in the republic of Panama, the author, recently H.M. Ambassador at Panama City, suggests that there are particularly good prospects for the sale of goods in a semi-manufactured state ready for final assembly by local labour. Panama is an expanding dollar market where competition is on a free and unrestricted basis, and British trade, at present, amounts to only 4 per cent. of the total. Apart from the United States, the most serious competitors for the market are Germany and Japan, and the survey gives hints to prospective United Kingdom exporters on such points as preparing quotations in dollars, furnishing trade literature in both Spanish and English, etc.

The Strength of Timber Struts. By J. G. SUNLEY. Forest Products Research Special Report No. 9. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.*2. (1*s.* 6*d.*)

This publication gives the details of the results of tests made on timber struts of the type used in light constructional work. The struts covered a wide range of size and quality, the woods used being Douglas fir, Sitka spruce, Scots pine and Baltic redwood. Various formulae, and the assumptions on which they are based, and their application to timber are discussed in relation to the test results. Two points of particular note are the use of statistics in the estimation of working stresses and of the observation of lateral deflections when estimating the crippling load of timber struts.

Strength and Stability of Walls. Building Research Station Digest No. 75. *H.M. Stationery Office, Kingsway, London, W.C.*2. (3*d.*)

For many years now the Building Research Station has undertaken researches into building and structural techniques that had hitherto been governed solely by empirical rules. An example of such work is provided by the investigations made at the station into the strength and stability of walls, particularly those of conventional brickwork. The booklet that has now been published gives much of the background to this particular subject of wall strength in so far as the recommendations of the station have been absorbed in the B.S. Code of Practice CP111.

Machines for Handling Materials in Traditional House Building. Building Research Station Digest No. 76. *H.M. Stationery Office, Kingsway, London, W.C.*2. (3*d.*)

Although only a small degree of mechanisation is applied to the craft trades in traditional house building, the unskilled tasks of serving the craftsman can be greatly facilitated by the use of suitable machines. This new leaflet, prepared by the Building Research Station, describes several types of machine—barrows, hoists, elevators, and cranes with their ancillary equipment—and gives notes on the economics of their use.

The Public-Health Significance of Synthetic Detergents. Edited by PETER C. G. ISAAC and DOREEN E. PASCOE. Bulletin No. 2, Department of Civil Engineering, King's College, University of Durham. *Public Health Engineering Laboratory, King's College, Newcastle-upon-Tyne.* (5*s.*)

The problem of the breakdown of synthetic detergents when mixed with normal sewage is one that has received a great deal of publicity in recent years and, with the consumption of detergents in the U.K. multiplying fourfold between 1948 and 1952, the problem has become one of great importance. The present bulletin is an attempt on the part of the members of the Public Health Laboratory at King's College, Newcastle-upon-Tyne, to put the results of about 50 references (fully noted in the bibliography) into one small volume.

Cours de Résistance des Matériaux. By J. COURBON. *Dunod*, 92 *Rue Bonaparte, Paris* 6*e.* (7,400 francs.)

This extensive scientific work on the strength of materials is intended for engineers with an advanced knowledge of mathematics. The subject is developed from the theoretical sphere to that of applied mechanics in civil engineering. Problems involved in the case of reinforced and prestressed concrete construction, and differing from those associated with constructions in metal, are studied in greater detail than has been done in the past. Importance is attached to stresses, deformation, experimental bases and the theory of elasticity, but the major part of the work is concerned with the theory of structures (girders, determinate and indeterminate arches, braced girders, etc.). The problems involved are approached by various methods and are developed sufficiently to be put to immediate practical use. In this connection a chapter is devoted to recent methods of approximation for calculating girder systems. Important developments concerning problems of elastic stability are examined and the text is supported by numerous diagrams and mathematical formulae.

Grundbau-Taschenbuch. Vol. I: Grundlagen, Baumittel, Bauformen, Bauverfahren. Vol. II: Normen, Richtlinien. *Wilhelm Ernst und Sohn, Hohenzollerndamm* 169, *Berlin-Wilmersdorf.* (Vol. I, 63 D.M.; Vol. II, 22 D.M.)

A number of writers contribute towards the compilation of this manual on foundations. It brings this type of construction into a class of its own and presents the knowledge gained from research so that operations can be safely and practically based on accepted principles instead of uncertain estimates and trials. The manual provides engineers with the important theoretical and practical principles for footings and foundations, grouped in such a way as to provide a reliable, handy reference for designing and executing work of this description. It is not intended to replace existing text-books, and literature references at the end of each contribution provide introductions to other works dealing with certain aspects in greater detail. The first three sections comprising vol. I deal with theoretical principles; materials and types of construction; and methods. It contains 1,207 illustrations and 169 tables. The fourth section is issued separately as vol. II and includes all the important German standard specifications and guiding principles relating to foundation constructions. There are 88 diagrams, 42 tables and an index by which standard specifications can be found according to their serial number.

ENGINEERING SPECIFICATIONS

A GUIDE TO EFFECTIVE PREPARATION

By Gregory F. Webb, A.F.R.AE.S., M.I.A.S.*

Specifications form the basis of all project work. Their proper presentation and use are of vital importance to every engineering achievement. The general characteristics and uses of engineering specifications are described in this article, and an outline for a method of compiling them is suggested. This is not intended as an inflexible set of rules to include every case, but rather as a practical guide to the avoidance of the more elementary pitfalls of specification writing. It could also form the basis of a technique for using specifications, though such techniques must, of course, be acquired and improved by each individual, through experience.

Specifications and Statements of Requirements

An engineering specification is essentially a description of a projected object or work of engineering. Its purpose is to define the boundaries of the responsibility which is delegated by whoever commissions the work to those who design and/or supply it. It is compiled by an originator of the work—either maker or user—who specifies its intended state or condition at some particular time: either the time of completion of the object concerned, or the time of conclusion of an agreement or contract between the supplier and potential user. "A specification must consider not only what is possible, desirable and necessary, but also what is practical, either now or in the near future." (E. H. Heinemann).

Since the specification is a device for the communication of the intentions of either supplier or user, it inevitably reflects the outlook of its originator. Thus the specification of an article written from the supplier's viewpoint may differ greatly from the user's description of the same article; the manufacturer may tend to emphasise form and design characteristics, while the operator may stress the function or performance required. In order to differentiate between a supplier's and a user's specification, the latter is usually and correctly termed a statement of requirement. However, no specification or requirement is complete or fully suitable for use as the basis of any agreement unless it defines both what the object specified is to be and what it is intended to do.

No formal specification is necessary where the requirement to be met is very simple. In such a case the definition of the proposed article may be included in (or appended to) the user's initial letter of inquiry, or in the supplier's quotation.

Functions of a Specification

The primary functions of a specification are:

(1) To provide the basic outline or to record the standards to which the article concerned is to be designed, developed or produced.

(2) To provide the factual basis of a transaction—e.g., a contract or agreement—involving the article specified, by defining the state of the work at the time of the transaction.

(3) To provide a check-list for ensuring that the article has been correctly assembled or completed.

(4) To provide the basis for defining the necessary functional checks or test schedules.

(5) To relate together the facts necessary to advertise and to sell the article.

(6) To provide a means for checking that the article received by the user meets in every way the requirements specified to the supplier.

(7) To record the original state of the article, to which subsequent alterations or modifications can be related.

Compiling the Specification

Specifier's Attitude

(*a*) The aim must be to produce the desired object or work of engineering in the simplest possible way. This necessitates a specification which is clear, concise and complete. The specification must be regarded as a tool or method for producing a result, and not as an end in itself.

(*b*) The specification sets the standards for the completed work. The engineer must ensure that these standards are completely adequate, though not excessive, for the purpose required.

(*c*) The specification sets the tone of any related transaction. As a communication, its tone must invite co-operation. As the product of an engineer, it must be honest and fair; whatever risks may result from the transaction must not be borne entirely by the recipient of the specification, and he must be advised by it of any particular difficulties which may be anticipated in completing the work.

Preliminary Action

Know the Users and their Needs.—The specification must be written in terms which are easily understood by all concerned. It saves time to list during preparation all probable recipients, their needs, and the actions required of each.

It may prove advisable to formulate the specification in terms of an existing article familiar to all concerned. In such a case it is important to define clearly the points of difference between the familiar and the projected objects, and to ensure that details of the existing standards are made easily available.

Collect and Classify all Relevant Data.—Facts are the basis of every work of engineering, and proper fact control is essential to ensure the inclusion of every relevant factor affecting the product. The greater the experience of those concerned, the fewer new facts are required to establish the form of the product. Nevertheless, facts adequate in numbers and content must be included to meet the needs of the least experienced of those using the specification.

Fact control requires:

(i) Means of obtaining information. Sources must be reliable, specific and up-to-date;

(ii) means of identifying sources; each fact must be self-contained, clearly identified as to nature and origin, and dated;

(iii) means of classification. This requires the facility to relate together similar subjects; separate dissimilar subjects; locate them; and recover them, subsequent to storing.

Place all Data in Logical Order.—Since facts are normally classified quite arbitrarily, they must be arranged in logical order—e.g., in the sequence of their date of origin, and of their importance to the project. The relative importance of each must be considered and understood. All but the essential factors should be eliminated at this stage. It is a help to have each fact set out on a separate paper or card as far as possible, in order to assist in handling and rearranging the material.

Writing the Specification

Since engineers are unfortunately not generally renowned for the quality of their communications, a procedure is here set out in detail with the object of providing a basis on which to work, in order to achieve at least the minimum standards necessary for producing an effective specification. This should not, however, be regarded as an inflexible guide or set of rules. The nature of the work and the engineer's experience are the only final arbiters.

(1) *Prepare a rough outline.*

Outline the basic requirements of the object in use: What must it do ? What is its environment in use ? Outline the basic requirements of its form: What is it to be ? Define the essential physical characteristics: dimensional limitations, strength, weight, etc. It may be of assistance at this stage to study a description of a similar article to that being specified.

(2) *Define the title.*

The title must be completely descriptive, but also concise and simple.

(3) *Decide the subject headings.*

Arrange a separate section for each major part or aspect of the project. Collate all relevant facts under each heading.

(4) *Determine the content of each section.*

Connect each series of facts into its most useful sequence. Formulate each requirement in relation to these sequences. Concentrate on the content of the material at this stage; its grammatical form may be left until later.

(5) *Make it "crystal clear."*

Use simple language. Keep words and sentences short, unless complexity is unavoidable. Consider the punctuation carefully; use the minimum number of punctuation marks consistent with achieving the precise intended meaning. Make certain that no doubt can arise about the point of any sentence.

Be positive: use concrete words and phrases, and avoid the vagueness of the abstract or the indefinite; it is better to avoid the use of pronouns, even at the expense of frequent repetition of the nouns. Otherwise, avoid unnecessary repetition or duplication throughout the work.

(6) *Specify durability or reliability.*

Ensure that sufficient attention has been paid to assessing the durability or reliability of the article concerned. Where means are quoted for checking that the specified performance or characteristics are achieved, these should be either permanent and recognised standards, or they should be completely and accurately defined.

(7) *Revise each section frequently.*

Review the completed paragraphs as succeeding ones take shape. Re-draft each in the light of later thoughts, where necessary. Introduce relevant new material if it becomes available.

(8) *Check carefully.*

Make certain that the main essentials have been included; that every factual statement has been independently cross-checked where possible; that title, date, origin, originator and issue number are prominently displayed; that no duplication occurs between the specification and any related document or contract; that no item is included which will not be required or enforced.

Use of Specifications

The ultimate usefulness of a specification depends on the extent of its availability to all those concerned with its many functions. Where an agreement is involved, adequate numbers of up-to-date copies should be provided for transmittal to signatories, and to their executive agents.

Every specification should be maintained in up-to-date condition. A master copy should be held separately available for immediate incorporation, in draft, of changes in state or of future requirements, as they occur. Amendments should be incorporated in such a manner as to leave no doubt as to the original form of the specification, or of the sequence and content of subsequent alterations to the article specified.

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THE NEWER METALS

By P. W. Wigram, B.A.

Should an engineer chance to examine Mendeleef's periodic arrangement of the elements, he might wonder why some metals have become of great commercial importance and others not. Why, for example, of the light metals, lithium, beryllium, sodium and magnesium, the last is the only one which is of major interest in engineering? Small quantities of beryllium are used alloyed with copper; sodium is of no interest for obvious reasons, but what of lithium? If he has non-ferrous metallurgical interests he may have heard that it forms disappointing alloys with magnesium. Yet pure lithium may well be a metal with a considerable future in the field of atomic energy.

The group containing tin and lead also contains titanium and zirconium; that containing nitrogen, phosphorus and arsenic, for which the metallurgist probably has few friendly feelings, also includes vanadium, columbium and tantalum. Chromium, molybdenum and tungsten are in the same group as oxygen and sulphur while manganese cobalt and nickel come close to iron. Most of these metals, in particular chromium, manganese, molybdenum, tungsten and vanadium, and to a less extent titanium, columbium and tantalum, are best known in the form of ferro-alloys. A proportion, in particular of tungsten, vanadium and tantalum, but also of chromium, molybdenum, columbium and titanium, are converted to carbides or in some cases are used as hard metal for facing softer materials subject to exceptional wear or corrosion. Taken by and large, however, it is normal to consider these metals either as ferro-alloys or carbides and to neglect their possible use in pure form or in alloys with other non-ferrous metals.

INFLUENCE OF IMPURITIES

It has been known for many years that the physical and mechanical properties of a pure metal may be very different from those of the impure metal even though there may be less than one or two per cent. of impurity in the latter. There are now numerous striking examples of the presence of even small amounts of impurity making a metal quite unsuitable for a particular purpose. For example, considerable effort has been expended in finding ways of making pure germanium for diodes and triodes. The search led to a particularly elegant method, devised in the United States, of zone melting. Titanium, as is well-known, becomes virtually unworkable with small amounts of impurity. Zirconium, which may be employed as an alternative to beryllium for casing uranium rods in atomic piles, must be free from hafnium to be of value for this purpose. The production of high-conductivity copper is an example among the common non-ferrous metals.

For the greater part of the output of the engineering industry, mild and low-alloy steels and the commoner non-ferrous metals and alloys have all the properties required and there is no point in the manufacturers of general engineering equipment going outside this considerable range of materials of construction. This is not always the case with the newer technologies employed in the chemical and process industries, gas turbines, atomic energy and the like. Traditional materials of construction are frequently inadequate in that although they can be used, their employment imposes undesirable restrictions which reduce the efficiency of the process to be operated.

When this type of problem occurs it is natural to seek a material of construction which will not impose such restrictions, with the result that extensive research has been carried out on a vast range of ferrous and non-ferrous metal alloys. A very large number of alloys have been investigated and are presumably available (or can be made) to meet nearly any particular requirement, but those of commercial interest are relatively few.

When faced with a new problem involving, say, operation at high temperature or pressure, or in conditions calling for considerable corrosion resistance, tensile strength at extreme temperature and the like, the engineer has to make a difficult choice.

INFLUENCE OF ALLOYING CONSTITUENTS

It is in part, though not wholly, true that by adding an alloying constituent, such as chromium, to iron the latter acquires some of the properties of chromium. Since iron is cheap and chromium expensive there are obvious advantages in being able to dilute a small amount of chromium with a large amount of iron and greatly improve the properties of the latter. Since a number of alloying metals are available and each additional metal imparts to the alloy some of its own individual properties the number of possible combinations is very large. However, alloys with too many constituents may become, in a sense, "unstable" in that after fabrication, for example welding, weaknesses may occur and failure take place. It then becomes necessary to make additions of columbium or tantalum to prevent this happening.

The Americans have investigated, and use, a range of alloys for gas turbines consisting basically of cobalt and chromium, but containing also molybdenum and tungsten. In general, the composition of cast and wrought alloys differs and the latter usually contain a proportion (from 1 to 4 per cent.) of columbium and/or tantalum. Recent developments in this field relate to the use of a ceramic-coated (cermet) metallic base or of bonded carbides, titanium carbide (50 to 60 per cent.) bonded with a nickel-chromium or cobalt-chromium alloy being typical. Chromium (30 per cent.) bonded with alumina (70 per cent.) shows exceptional stress-rupture properties at 1,796 deg. F. but is virtually unworkable.

Gas-turbine blading offers special problems. Moreover, its strategic importance has resulted in a great deal of research being devoted to the discovery of materials having not only considerable stress-rupture strength at high temperatures but also corrosion resistance. Low-alloy steels and the commoner non-ferrous metal alloys are totally inadequate under such conditions, which, though they are exceptionally severe in gas-turbine service, nevertheless occur with increasing frequency in other fields. Those who have occasion to go through the metallurgical abstracts published in the *Journal* of the Institute of Metals, must have been impressed by the amount of work on the newer metals undertaken by the atomic-energy authorities both in the United Kingdom and, more particularly, America. Similar problems face the petroleum-refining industry, where temperatures rise steadily; the manufacturers of high-pressure steam boilers which are required to burn fuels containing sulphur, sodium and vanadium, and the process industries generally, where temperatures rise and operating conditions become increasingly severe.

In the United Kingdom there has been a general tendency to employ stainless steel (columbium-stabilised where possible) to meet corrosive conditions in the process industries and ferritic steels for high-temperature operation in steam boilers, gas-turbine rotor discs and the like. Only in the case of gas-turbine blading, combustion chambers and parts subject to direct flame impingement, have non-ferrous alloys of the newer metals been widely used. In the United States the newer metals and their alloys have been much more extensively employed and the argument is sometimes advanced that it is because America is a rich country and can afford to buy them. There may be some measure of truth in this, but the fact should not be overlooked that prior to the Korean war the United States had developed along these lines, whereas the British had tended to develop the cheaper iron-base alloys. When the Korean war took place, these scarce metals, in their ores and concentrates, were subject to allocation, based on the consumption in earlier years, with the result that America generally obtained a good deal more than anyone else—in the case of cobalt she obtained over 60 per cent. of the world output (excluding Communist countries). Since the end of that war the position has eased gradually, but this has not involved a re-orientation in demand nor a new emphasis on finding fresh outlets for the consumption of the newer metals in this country.

The newer metals include those commonly employed as ferrous alloys, namely, chromium, cobalt, manganese, molybdenum, nickel, tungsten, and vanadium, and others such as columbium and tantalum (also used in ferro-alloys) and titanium and zirconium.

COST OF THE METALS

For a variety of reasons connected both with the scarcity of their ores, but also the cost of extraction, these metals are expensive. There are no quotations for columbium and tantalum or titanium and zirconium. Tantalum powder used to be around £16 per pound and wrought forms between £20 and £30 per pound in the United Kingdom. The current price in the United States is about £22 10*s*. per pound for rod and £15 per pound for sheet. Titanium metal (99·3 per cent.) is £1 10*s*. per pound and zirconium £2 10*s*. per pound for the powder, both in the United States. The prices of other metals are as follows :

Chromium, 98/99 per cent.	per lb.	6*s*. 7*d*. to 7*s*. 1*d*.
Cobalt	„	21*s*.
Manganese, min. 96/98 per cent.	per ton	£225 to £262
Molybdenum powder	per lb.	30*s*. to 40*s*.
Nickel, 1 ton and over	per ton	£519
Tungsten powder, 98/99 per cent.	per lb.	19*s*. 9*d*.

What have these rare and expensive metals to offer? Columbium, other than as ferro-columbium, is of little interest, though it has good corrosion resistance and its high capacity for absorbing gases makes it of potential value in electronic engineering. It has a specific gravity of 8·57 and the relatively high melting point of 2,415 deg. C. The tensile strength of annealed sheet lies between 21 tons and 22 tons per square inch. At present, it is far too rare and expensive to be of interest in pure form.

TANTALUM

Tantalum has exceptional corrosion resistance, and a melting point (2,996 deg. C.) exceeded only by tungsten (3,370 deg. C.) and rhenium (3,440 deg. C.). Its tensile strength is quite good (22 tons to 33 tons per square inch for annealed sheet*) and it has reasonable heat conductivity. Being of less interest as a ferro-alloy than ferro-columbium, there is a possibility that in due course it will be used at least to a moderate extent for chemical plant, particularly as it can be deposited, by the hydrogen reduction of the chloride, on both ferrous and non-ferrous metals and such non-metallic materials as quartz, alumina, graphite and various ceramics.

TITANIUM

So much has been written about titanium that there is no point in discussing it at length. Its exceptional strength/weight ratio and the fact that it has the combined properties of aluminium and stainless steel, has led to an enormous demand in the United States by the aircraft industry. In this country, unfortunately, it has led to a good deal of scepticism due to the fact that the quality of some of the material supplied has fallen well below expectations. The demands

* Worked sheet has a tensile strength of 56 tons to 76 tons per square inch.

of the aircraft industry, particularly for military aircraft, has meant that none is available for anyone else; in consequence too little is known of its excellent corrosion resistance, particularly to sea water, nitric acid, chlorine and caustic soda and quite good resistance to sulphuric acid. In certain respects it is as good as, and in some cases better than, stainless steel, of which it may form a minor constituent. It is reasonable to suppose that in due course the intense research effort being put into finding ways of making titanium more cheaply will result in there being more than is required by the aircraft industry. Then, either the pure metal in wrought forms, or clad metal, such as titanium-clad mild steel, will become available to chemical-plant manufacturers, and to shipbuilders and others who make equipment to withstand salt-water corrosion. It is unfortunate that its heat conductivity is not good but this is not an insuperable disadvantage.

ZIRCONIUM

Too little zirconium metal is available to offer useful comment on its commercial potentialities. Its properties are generally similar to those of titanium but its specific gravity (6·53) is considerably higher and in consequence the aircraft industry is relatively uninterested in it. It is nevertheless a potential material of construction for the chemical industry and it has exsisting uses, the importance of which it is difficult to assess, in the field of atomic energy. Manufacturers of the metal consider that it is a useful material of construction for plant to handle hydrochloric acid, since its corrosion resistance is nearly as good as that of tantalum, whereas its specific gravity is only about one-third so that it is likely to be significantly cheaper. The metal also has applications in the electronics industry, partly as a flux for welding tungsten to tungsten or tungsten to molybdenum, and partly on account of its capacity for absorbing large quantities of oxygen, hydrogen and nitrogen at relatively low temperatures.

CHROMIUM

The properties of the remaining metals, chromium, cobalt, manganese, molybdenum, nickel, tungsten and vanadium are reasonably well-known.

Chromium metal is used as such in the form of plating, but its main outlet is in high-temperature alloys, with nickel. Chromium itself has exceptional resistance to corrosion and to high-temperature oxidation owing to its capacity to become, and remain, " passive." It is best used in oxidising conditions and the protective oxide film which is formed on the metal surface is rapidly destroyed by, for example, hydrochloric or sulphuric acid.

COBALT

Cobalt, which has the relatively-low melting point of 1,480 deg. C., is mainly employed as a binder for cemented carbide tools, for example, tungsten and tantalum carbides. It can be alloyed with steel to improve the cutting efficiency of high-speed tool steels at high temperatures and with iron, tungsten and chromium, or iron, nickel and aluminium to give permanent-magnet alloys. The ferritic steels are used for gas-turbine discs. The non-ferrous alloys of cobalt, such as the "Stellites" which contain cobalt chromium and tungsten, sometimes in conjunction with molybdenum, nickel and iron, are also of great importance for chemical plant, cutting tools and, on account of the fact that they do not oxidise or distort at high temperatures, for exhaust valves and valve seats in aircraft and Diesel engines. At present there seem to be few uses for cobalt metal as such, most of it being employed in alloy form.

Manganese metal (specific gravity 7·2, melting point 1,244 deg. C.) is overwhelmingly used in ferro-alloys, though some is employed in bronzes (aluminium and manganese bronze), Constantan and nickel-chromium resistance alloys.

MOLYBDENUM

The greater part of the output of molybdenum (specific gravity 10·2, melting point 2,620 deg. C.) is employed in ferro-alloys, grey-iron castings or certain low-alloy steels, but the pure metal, on account of its very high melting point, is used by the electrical industry as a heating element in high-temperature furnaces and for contact points. It may be, as noted above, one of the alloying constituents in " Stellite." There have been somewhat sensational forecasts in the United States of its potential application as a coating material for jet-engine blades and as a constituent of tools working under hot conditions. The President's Materials Policy Commission, which reported in 1952, forecast that there was a potential annual American demand for metallic molybdenum, by 1975, of 70 million lb., and that a further 26 million lb. would be required by the rest of the world. Consumption for jet engines alone would rise to 15 to 20 million lb. per annum in the United States. It is difficult to offer useful comment on this for the reason that present research developments in the United States for gas-turbine blading seem to be directed away from metals in the direction of bonded carbides.

In cases like this, where developments are taking place with great rapidity, forecasts of this nature are bound to be highly speculative. The difficulty here is that the melting point of molybdenum is so much higher than that of any other metal it is likely to coat (it is exceeded only by tungsten, tantalum, rhenium and osmium) that it will be necessary either to use cooled blades, which would probably make the employment of molybdenum unnecessary, or else employ bonded carbides, which again do not at this stage seem to require a metallic sheath. The fact remains that molybdenum and tungsten are two metals likely to be of increasing importance to those who require to deal with very high temperatures. Apparently high-molybdenum alloys are subject to both oxidation and volatilisation at very high temperatures, but it is uncertain whether both are due to the molybdenum or to alloying constituents.

The uses of nickel, like those of chromium, are sufficiently well known not to require discussion. The pure metal is employed in electrical storage batteries (Ni/Fe cells), in the electronics industry and for laboratory ware. In chemical processing it is widely used as a catalyst in the petroleum, synthetic-rubber and oils and fats industries (cobalt and molybdenum are also employed as catalysts, but less extensively). It is a hard, strong, corrosion-resistant metal which, like chromium, becomes " passive " owing to the formation of an oxide layer. The specific gravity is 8·90 and the melting point 1,452 deg. C. Apart from its ferro-alloys, which include stainless steel, it is most widely employed as Monel, a nickel-copper alloy containing 63 to 69 per cent. nickel and 29 to 32 per cent. copper.

TUNGSTEN

Ferro-tungsten, for high-speed steel, armour-piercing shell tips, magnet steels, valve seatings, etc., tungsten carbide for abrasives and the previously mentioned " Stellite " alloys, absorb practically the whole output of this metal. It has, however, nearly the highest melting point of all metals (3,350 deg. C.), a specific gravity of 19·3 and resistance to almost all chemicals, an exception being a mixture of nitric with halogen acids (hydrochloric and hydrofluoric). When properly treated it is very elastic and ductile. It has a tensile strength of up to 265 tons per square inch and may be drawn into very fine wires, so that its main outlet is to the electrical industry for electric-lamp filaments, and heating elements.

In the United States the output of tungsten-metal powder, most of which is used for carbide production, is increasing in proportion to the output of ferro-tungsten. Its high price, in part due to the Korean war and United States stockpiling, but also to a limited supply of concentrates, has undoubtedly discouraged consumption. It has, however, outstanding properties for which, in due time, uses will be found. Moreover, like nickel and chromium, tungsten can be plated on to relatively inexpensive alloys such as brass and bronze. While of no value for high-temperature applications, this does permit uses to be found for its excellent corrosion resistance.

VANADIUM

Vanadium metal at present has no recognised uses other than as a ferro-alloy. It is, however, being produced in ductile form, together with columbium, at the United Kingdom Atomic Energy Authority Research Station at Culcheth in Lancashire. A considerable amount of extraction and powder-metallurgy research, including work on lithium, is being carried out at this research station, which is one of at least five, the others being Harwell, Springfields, Capenhurst and Windscale, maintained by the Authority. It emphasises the point made above, namely, the interest in the newer metals shown by atomic-energy authorities in this country and elsewhere.

It is reasonable to suppose that in the course of a decade or two these newer metals will become cheaper and more generally available. They will cease to be thought of simply as constituents of ferrous or non-ferrous metal alloys. For a long time, possibly indefinitely, most of them may be too expensive to use other than as a surface coating on a mild-steel or a non-ferrous base. Even so, it may well be found that, for example, a tungsten layer on a non-ferrous metal gives properties which are a marked improvement over tungsten in the form of a non-ferrous alloy.

* * *

LIGHT-ALLOY CLADDING FOR BUILDINGS

Concealed Fixing

A standardised roof and wall cladding, using profiled " Kynal " aluminium-alloy sheets and known as the " Kynalok " Secret-Fix system, is being marketed by Imperial Chemical Industries, Limited. The adjacent sheets are held in position by an extruded aluminium-alloy cover strip, designed to accept on its underside the head of the fixing bolts. These in turn are secured to the purlins or sheeting rails by special straps. Provision has been made for incorporating insulation or other lining boards behind the cladding.

The system is designed to span up to 7 ft. 6 in. on roofs of a minimum pitch of 10 deg., and 10 ft. on walls, these recommended spans being based on the results of loading tests carried out by the Building Research Station. Loading tests proved that the system adequately satisfies all the requirements of the British Standard Code of Practice 3 (chapter V, " Loading ") with a safety factor of two, as requested by the B.R.S. authorities, for point loads and uniformly distributed loads, including suction.

The insulating lining, together with a 2-in. air space created by the sheet profile, and the high reflectivity and low emissivity of aluminium combine to give calculated U values of 0·171 for the still-air conditions and 0·238 with a 15-m.p.h. wind on the outside face, both values being lower than the 0·3 afforded by an 11-in. unventilated cavity wall.

Both cladding and insulation are erected at one and the same time using fixings common to both, and the simplicity of the system enables erection technique to be readily learned. The profile of the cladding sheets provides an attractive appearance which is unbroken by protruding bolt heads. The fact that the sheets do not have to be drilled means that they are wholly re-claimable, and the cladding may readily be dismantled and re-assembled when necessary. The absence of bolt holes eliminates the possible source of leakage which can arise from the enlargement of such holes by the thermal movement of the sheets. The K.S.F. system is being marketed by I.C.I. under licence to approved roofing and building contractors.

TESTS ON PARALLEL-SURFACE THRUST BEARINGS

OPTIMUM CONSTRUCTION FOUND BY EXPERIMENT

By C. F. Kettleborough, B.ENG., PH.D., A.M.I.MECH.E.*

An experimental determination of the film thickness, coefficient of friction and the oil-film pressure has been made for parallel-surface thrust bearings. The results indicate that a circular annulus with four grooves is to be recommended for maximum operating film thickness and for minimum friction.

Although parallel-surface thrust bearings have been known for many years, and were in fact used for accommodating thrust before the introduction of the tilting-pad bearing in about 1908, very little experimental work has been carried out on these bearings. Fogg[1] demonstrated that under certain conditions of high speed, hydrodynamic lubrication exists between the bearing surfaces; he postulated the principle known as the thermal wedge to explain, in part, its performance. Further theoretical work has been carried out by Bower,[2] Shaw[3], Cameron and Mrs. Wood[4], and Cope.[5]

This article describes the results of experiments in which the oil-film thickness, the coefficient of friction and the oil-film pressure have been determined at relatively slow speeds.

EXPERIMENTAL EQUIPMENT

The experimental equipment is shown in Fig. 1. The vertical shaft *a* carries a lead-bronze thrust ring *b*, the plane faces of which rotate between two plane mild steel thrust bearings *c* and *d*. The lead-bronze thrust ring is flexibly mounted by supporting it in the gymbal *e*. The lower thrust bearing *d* fits directly into the thrust casing *f*. The upper thrust bearing *c* is carried in a carrier ring *g*. Three equally-spaced radial grooves are machined in the upper face of this carrier ring. The load is applied hydraulically to three pistons *h*, located in the casing cover *i*, and transmitted by three balls, one being located in each groove. Hence the upper thrust bearing is accurately located. The vertical shaft is located in the thrust housing by a self-aligning ball bearing *k* and a roller bearing *l*. The latter can be separated to facilitate the removal of the cover. The thrust housing and shaft are supported in two roller bearings (not shown) which are carried in a suitable supporting framework.

The plane thrust bearings used were annular rings of $2\frac{1}{4}$ in. internal diameter, and $4\frac{1}{8}$ in. outside diameter, with oil grooves $\frac{3}{16}$ in. wide and $\frac{1}{8}$ in. deep. The rings were very finely ground all over and finished by lapping. They were checked for flatness and parallelism on a surface plate using a Talymin gauge and there was a variation of less than $1{\cdot}0 \times 10^{-4}$ inch over the surface. The rotating thrust bearing, which was made of lead bronze, was finished on both sides by the spot-grinding process producing a surface with a very high degree of flatness.

The bulk oil temperature was measured at two points within the casing (approximately at positions A and B in Fig. 1). These two temperatures were sensibly the same, and were used to determine the value of the viscosity Z in the parameter $\frac{ZN}{P}$.*

Oil entered the bearing at the position indicated and was emitted at the top. A positive oil pressure of about 5 to 10 lb. per square inch was maintained in the oil casing.

OIL-FILM THICKNESS

The operating oil-film thickness was determined by measuring the lift of the pin connected to the upper thrust surface, the measurement being made by air-gauging techniques. An initial reading was taken with the thrust ring revolving and the hydraulic load applied to the bearing. The shaft was stopped and a second reading was taken. The lift measured was assumed to be equal to twice the mean film thickness, that is, the two oil films are equal and no residual oil films exist, or are negligible, when the shaft is stationary.

Fig. 2 shows the typical experimental results showing the deviations and experimental spread obtained. Although the latter may seem large, the magnitude of the actual displacements must be noted. However, a mean curve can be satisfactorily drawn through them.

Fig. 3 shows the film thickness for pads having three, four, five and six grooves. Experiments were also carried out with pads having two and no grooves; satisfactory running was achieved but the oil film thickness was very small, the readings obtained erratic, and the bearing became overheated, particularly with the ring without grooves.

The results suggest an optimum number of grooves of four. A possible explanation is that if the circumferential length between grooves is too long the side leakage reduces the film thickness; if the circumferential length is too short then the temperature rise is limited and hence the thermal expansion of the lubricant is too little.

All the above results were taken at a speed of 695 r.p.m. The dotted curves on Fig. 2 illustrate that an increase of speed to 1,025 r.p.m. causes an increase in the operating oil-film thickness. Although theoretically the increase in temperature of the oil passing through a bearing depends on the load rather than the speed, the temperature measured on the surface of Michell pads by Kettleborough, Dudley and Baildon[6] showed that the load had little effect, whereas the speed caused large changes in temperature. Hence for the parallel-surface thrust bearing, an increase in speed causes a larger increase in expansion volume due to the temperature rise and hence an increase in running film thickness.

FRICTION

The friction force at a radius of 10 in. was measured by weights and a spring when running under load and under no load; the difference in forces being the friction force due to the addition of the load. Fig. 4 shows the value of the coefficient of friction plotted against the parameter $\frac{ZN}{P}$. Minimum friction is obtained for the four-grooved thrust ring, that is, when the oil-film thickness is a maximum. The coefficient of friction increases for rings with other than four grooves for which the film thickness is less. No significant variation with the two speeds considered was found. It is to be noted, however, that the coefficient of friction (assumed acting at the mean radius of the pad rings) is much greater than that given by Fogg.[1]

OIL-FILM PRESSURES

Fig. 5 shows the four-grooved pad drilled with pressure search holes (No. 69 drill) and the technique of connecting each hole *via* a small valve to a common circular manifold, which is in turn connected to pressure gauges. Extreme difficulty was experienced in obtaining oil-film pressures and extreme patience was required. The rate of oil flow from the search holes was only of the order of 1 or 2 " drops " per minute. In order to decrease the time of recording pressures, the manifold circuit was externally pressurised by the pump supplying the hydraulic load. After being pressurised to a certain value with one of the search-hole valves open, and with the bearing operating at a steady load and

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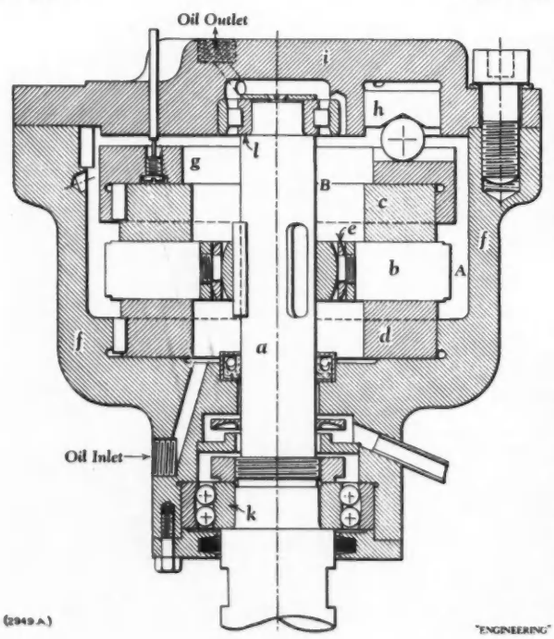
* Z is in poise, N is in r.p.m., and P is the bearing load in lb. per sq. in. (limited to about 130 lb. per sq. in. by limitations in the loading system).



(2949.A) "ENGINEERING"

Fig. 1 The apparatus used for determining the oil-film thickness, the coefficient of friction and the oil-film pressure for experimental parallel-surface thrust bearings. Hydrodynamic lubrication was proved, but the operating film thickness was less than for the tilting-pad bearing and the coefficient of friction very much greater. Oil temperatures were measured at two points, A and B.

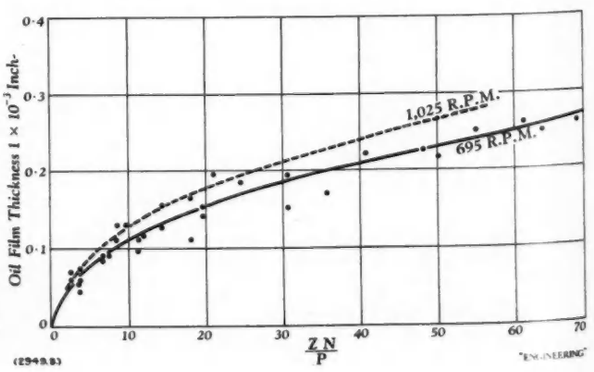


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Fig. 2 Variation in the film thickness with increase in the parameter, $\frac{ZN}{P}$. The scatter of the measurements is shown for a three-grooved collar bearing rotating at 695 revs. per minute.

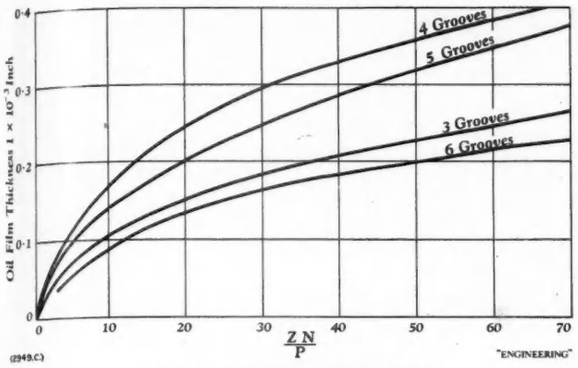

Fig. 3 Variation of film thickness.

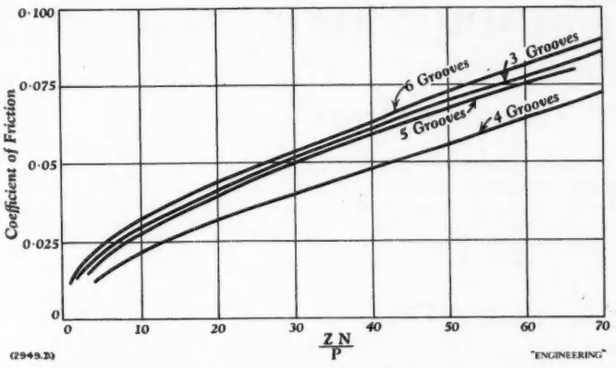

Fig. 4 Variation of coefficient of friction.

Figs. 3 and 4 The variation of the film thickness and coefficient of friction with increase in the parameter $\frac{ZN}{P}$ for bearings with different numbers of grooves. It is apparent that, for the size of bearing examined, four grooves gave the best results.

temperature, careful observation was made to ascertain whether the pressure increased or decreased—10 to 15 minutes wait was sometimes necessary. Depending on the sign of this pressure change, the manifold pressure was changed by an increment of 10 lb. per square inch in the direction indicated by this pressure change until the change of pressure from the set value changed sign. Hence a limited range, between which the oil-film pressure lies, was known. The set pressure was then changed by 5 lb. per square inch and the oil-film pressure was allowed to stabilise. By this means—with the expenditure of much time—oil-film pressures were recorded as is shown in Fig. 6. Six pressure-search holes were located in each quadrant of the plane pad; in each case the holes lay on the same circumferential arc. An examination of the pressures enables certain conclusions to be drawn. The fact that along any circumferential line a smooth pressure curve cannot be satisfactorily drawn suggests that waviness or high spots occur. The mean oil-film thickness from Fig. 3 is only about $0{\cdot}14 \times 10^{-3}$ in. and very small surface undulations will cause converging and diverging oil films. Along the inner circumferential line near the outlet edge a pressure of 90 lb. per square inch was recorded consistently with markedly lower pressures on adjacent holes, thus suggesting a local high spot near the 90 lb. per square inch search hole. The film pressures tend to be somewhat higher towards the leading edge due to the higher viscosity existing there as compared with that occuring in the trailing half of the quadrant.

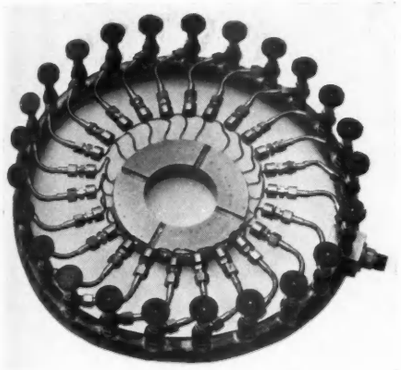

Fig. 5 The search holes and pressure connections in the four-grooved bearing. Each hole was connected through a small valve to a common circular manifold which, in turn, was connected to the pressure gauge.

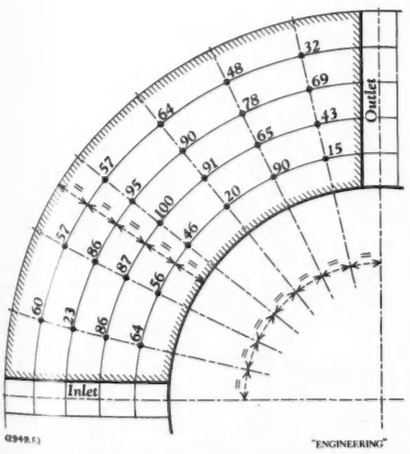

Fig. 6 Map of oil film pressures, in lb. per sq. in., across a quadrant of the four-grooved pad The applied bearing load was 53 lb. per sq. in., the speed of rotation 695 revs. per minute and the operating temperature 139 deg. F. Under these conditions the parameter $\frac{ZN}{P}$ had the value of 7·5.

Although it is realised that the overall pressure distribution is far from satisfactory, no further attempt has been made to improve this, it being considered that the time required for improvement would hardly justify the ends. Bearing surfaces of a very high degree of flatness are obviously necessary.

CONCLUSIONS

Sufficient experimental evidence has now been obtained to state that hydrodynamic lubrication exists in the parallel-surface thrust bearing. The operating film thickness is very much less than that for the tilting-pad bearing and the coefficient of friction very much greater. Shaw[3] has given some figures for the relative load capacity of the tilting-pad and the parallel-surface thrust bearing. For a temperature rise of 50 deg. F., the relative load capacity is 14, hence the relative film thickness is $\frac{1}{\sqrt{14}}$. A comparison of the film thicknesses of Fig. 2 and those given by Kettleborough, Dudley and Baildon[6] shows approximate agreement with this value.

Experiments were also carried out with a row of thermocouples attached to the circumferential centre line of the plain bearing. These thermocouples passed through the pad rings and after being firmly attached to the face of the bearing, the latter was re-lapped to produce the original flat surface. The results clearly indicated that although the temperature measured was much greater than the bulk oil temperature, there was no significant variation between the inlet and outlet edges for all the bearings. The thermocouples were calibrated in their actual working positions.

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SAFETY TESTS FOR PORTABLE ELECTRICAL APPARATUS

Many electrical accidents, some of them fatal, are caused by faulty earthing of portable apparatus. To be sure that equipment is in a safe condition it should be tested at regular intervals, and the tests should simulate working conditions as nearly as possible. An instrument to do this has been designed by British Central Electrical Company, Limited, 6 and 8 Rosebery-avenue, London, E.C.1, and is called the Briticent Full-Load Earth Continuity Tester. A heavy current is passed through the earth conductor of the portable tool, which ensures that if the conductor is nearly worn through it will burn out and not be left in a dangerous condition. The resistance of the earth conductor is indicated, and if it is too high a new lead can be fitted. It is suggested that the tester should be kept in the issuing stores, and all portable tools should be tested on release and return.

The instrument is contained in a polished wooden cabinet, and comprises a double-wound transformer, direct-reading ohmmeter, gas-discharge warning lamp, spring-loaded test button, mains inlet socket and plug, pair of steel crocodile clips, 15-ampere 3-pin test socket, and an earth terminal.

Another instrument made by the British Central Electrical Company is the Neutral Loop Impedance Tester which incorporates the full load earth continuity tester described above. The neutral loop tester is designed to test the earth resistance right round the neutral loop, through the local sub-station earth point. The same method of injecting a heavy current is used, and besides testing loop resistance and earth continuity the instrument indicates line and neutral and earth and neutral reversals.

INDUSTRIAL USES OF ATOMIC ENERGY

BRITISH EXHIBITS AT GENEVA

The International Conference on the Peaceful Uses of Atomic Energy is to open in Geneva on Monday, August 8, and concurrently with it two exhibitions are being held; one will be purely scientific in character and will take place in the Palais des Nations, while the other, in the Palais des Expositions, will be of a more general nature. In addition to exhibits provided by the United Kingdom Atomic Energy Authority, the British contribution will include displays by some 40 industrial firms and these will occupy a total area of approximately 20,000 sq. ft. The industrial exhibits will be in two sections, one devoted to heavy industry and the other to the instrument industry. Some of the items to be shown are described in the following article.

ELECTRON SYNCHROTRON

The stand of the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, will illustrate by means of actual equipment, models, drawings and photographs, some of the ways in which the company is contributing to nuclear-power development. Among the exhibits will be a model showing the form atomic power stations may take in the future, apparatus concerned in graphite research, an electron synchrotron for producing high-speed electrons, high-absorption shielding material, and models of uranium processing furnaces. Salford Electrical Instruments Limited, who are associated with G.E.C., will demonstrate an electromagnetic transducer system with applications in atomic factories, and a range of Geiger-Müller tubes for radiation monitoring.

Fig. 1 G.E.C. high-temperature high-vacuum furnace for measuring the creep behaviour of graphite specimens and for recording results cinematographically. Graphite is used as a moderator in nuclear reactors.

The use of graphite as a moderator in nuclear reactors is well established. It is somewhat less efficient than heavy water but its use is amply justified by its relatively low cost. Research has been carried out by G.E.C. into the high-temperature mechanical properties of this material and Fig. 1 shows a high-temperature high-vacuum furnace with special facilities for measuring the creep behaviour of graphite specimens and for recording results cinematographically. The graphite specimens take the form of helical coils made from extruded material and baked at 3,000 deg. C.

Fig. 2 shows the electron gun and Fig. 3 the glass " donut " and resonator of an electron synchrotron, which is a device for accelerating electrons to a high energy, giving them velocities closely approaching that of light. It is used in nuclear-physics research and to produce hard X-rays for deep therapy. Electrons from a thermionic cathode mounted in the electron gun are injected at an energy of 70 keV into an evacuated glass annulus or donut, which is placed in the field of an electromagnet so that the electrons travel in circular paths. The energy of the electrons is raised to between 2 and 3 MeV by increasing the magnetic flux, and finally reaches a value of 30 MeV by giving them an electrical impulse once in each revolution round the annulus. The energy of 30 MeV corresponds to an electron velocity of 99·98 per cent. of the speed of light. The machine operates on a 50 cycles per second supply, and the process of injection, acceleration and extraction of the electrons occupies one quarter of a cycle.

HEAVY ALLOYS AND INSTRUMENTS

Heavy alloys with densities in the range 16·5 to 18·0 gm. per cubic centimetre possess several advantages over lead as shielding materials against high-energy gamma radiation. Their higher linear absorption coefficients enable a reduced wall thickness, and therefore a lighter container, to be used for equivalent protection. For cobalt 60 or caesium 137 radiation the saving in weight is about 35 per cent. The alloy may be readily machined and containers and machined specimens will be shown on the G.E.C. stand.

The General Electric Company has made vertical cylindrical electric furnaces and ancillary equipment for the atomic factory at Springfields. These furnaces are employed in the conversion of ammonium diuranate to uranium tetrafluoride, which is then reduced to metallic uranium. Models of 100-kW furnaces, which have a heated

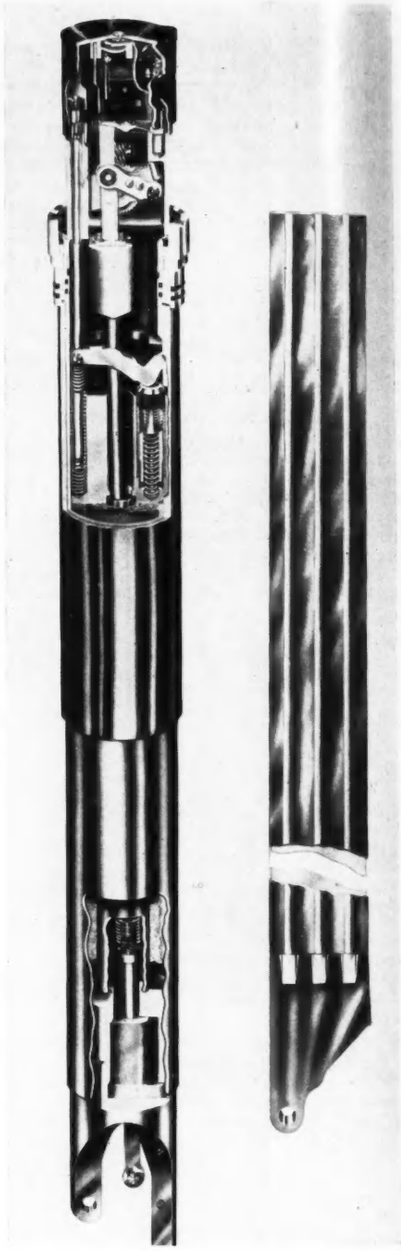


Fig. 4 Coarse control-arm unit, six of which are embodied in H. M. Hobson's control system for a thermal reactor.

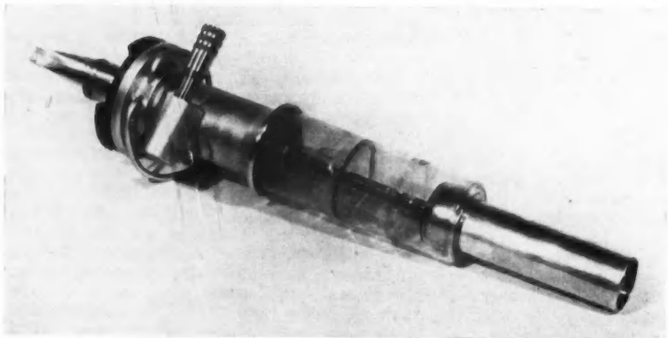


Fig. 2 Electron gun.

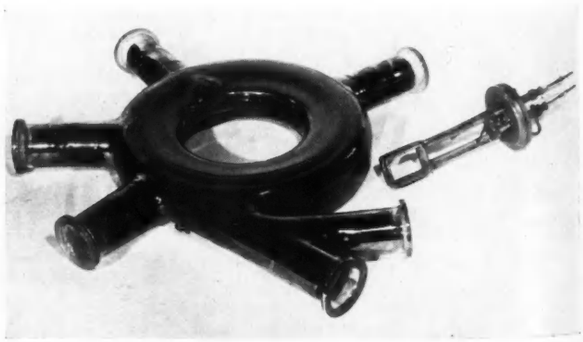


Fig. 3 Glass " donut " and resonator.

Figs. 2 and 3 Components of G.E.C. electron synchrotron designed to accelerate electrons to a high energy corresponding to a velocity approaching that of light.

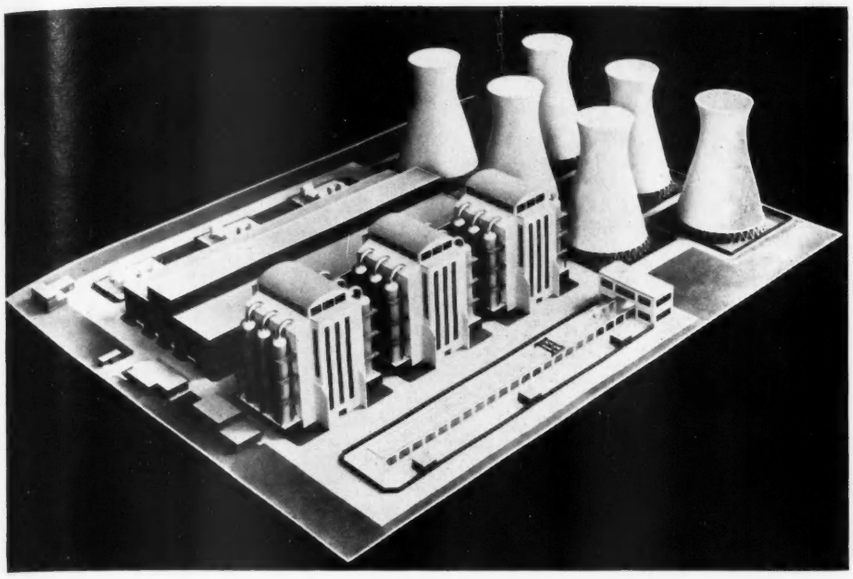


Fig. 5 Model showing the form that atomic factories may take in the future. On it are represented nuclear reactors and their associated heat exchangers and the "pond" for storing irradiated cartridges.

depth of 6½ ft., give a maximum temperature of 750 deg. C. and are cooled by forced air circulation, will be shown on the stand as well as samples of ammonium diuranate and uranium tetrafluoride, and a uranium fuel rod.

Various electronic instruments will be displayed by Salford Electrical Instruments Limited, including an electromagnetic transducer system for the remote indication of pressures and temperatures in atomic factories, notably for the gaseous diffusion process at Capenhurst where the fissile uranium 235 is extracted from uranium 238. Both halogen and organically quenched Geiger-Müller tubes for the detection of gamma and beta radiation at various strengths will be shown, for example the 5GH halogen-quenched gamma-radiation monitor tube designed for use as a probe in portable equipment. Corona stabilisers employed for stabilising Geiger counter or photo-multiplier supplies in the range 400 to 1,400 volts will also be on display.

A particular feature of the stand will be a model representing the shape atomic factories may take in the future. On it will be seen nuclear reactors with their associated heat exchangers, the building containing the coolant gas blowers and generating equipment, and the pond for storing "hot" or irradiated cartridges of nuclear fuel. The model is shown in Fig. 5.

REACTOR CONTROL SYSTEM

H. M. Hobson, Limited, Fordhouses, Wolverhampton, Staffs., will be exhibiting a control system for the type E.433 ("Dido") thermal reactor. The exhibit will comprise models and sectional illustrations of the control system. The unit has been developed in collaboration with the Atomic Energy Research Establishment, at Harwell.

The design of a control system for this reactor is conditioned by space limitations and must therefore be compact and arranged so that radiation cannot escape from the reactor to the surrounding spaces. In addition, the shielding must be sufficient to prevent parts of the mechanism which require servicing from becoming radioactive. Provision must also be made for replacing an active element without risk to operating personnel. Additional features include the provision of reliable bearings and gas seals in regions of high activity, the seals being necessary to prevent the escape of the helium blanket covering the heavy-water moderator. The approach to these problems adopted in the Hobson-A.E.R.E. system takes the form of a comparatively simple mechanical linkage passing through the reactor shield, with the controlling mechanism remotely situated.

The control system comprises three main sections: (1) a coarse control shut-off group, (2) a regulating or fine-control group, and (3) a safety-rod group. The general layout can be seen in Fig. 6. The controllers, which operate inside the reactor, are driven by gearboxes located on the outside of the reactor shield and remotely operated from the control room.

Six combined control and shut-off controllers of the signal-arm type, containing cadmium neutron absorbers, operate in the lattice spaces formed between the rows of fuel elements. The controllers are moved synchronously to increase reactivity at a slow rate, and are manually controlled to give an accuracy of movement of one minute of arc over the operating range of 56 deg., taking 25 minutes in either direction under normal operating conditions.

An additional "fast-in" speed is provided in which the controllers take five minutes to cover the operating range. Under emergency conditions, however, the controllers will "trip" (in less than one second) to shut down the reactor. This action is achieved by the release of a magnetic clutch situated between the controller and its associated gearbox. The controllers are driven remotely by a master gearbox situated in the control room not shown in Fig. 6, which employs Selsyn synchronous link power transmission to drive six slave gearboxes which, in turn, are mechanically coupled to the control-arm units.

CONTROL-ARM UNIT

Each control-arm unit includes a shielded plug portion which extends through the reactor top shield into the sealed reactor tank, to form a bearing at the lower end for the pivoted control arm. The plug portion houses the operating mechanism in addition to the necessary shielding material. In order to maintain adequate shielding in the plug portion, a simple linkage is employed to operate the control arm. This linkage is in the form of a pivoted lever and connecting rod assembly, the latter being in two parts which are coupled by an electro-magnetic link. The complete coarse control-arm unit is shown in Fig. 4.

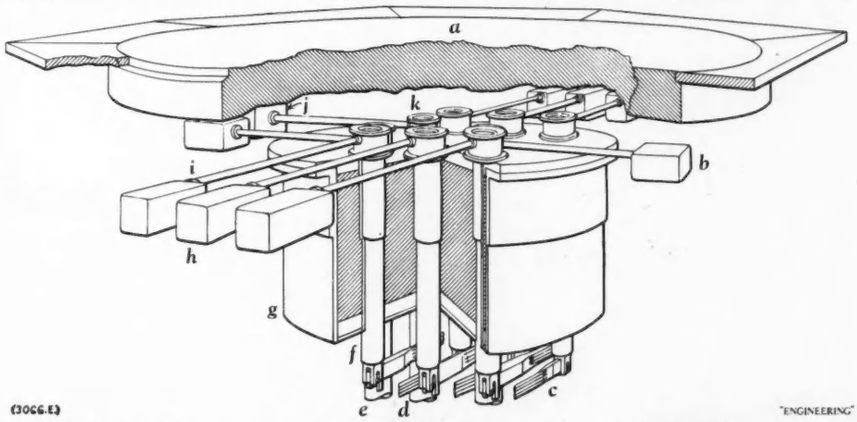
Under normal conditions of operation the rod is maintained integral but, following de-energisation of the electro-magnetic link, the control arm will fall freely under gravity to the 56 deg. or "in" position, where it is approximately in the centre of the core zone. To absorb the inertia of the cadmium-filled control arm, a spring assembly is incorporated.

The controller is horizontal when in the "out" position, while the "in" position is limited by a positive mechanical stop. This is necessary since the position of "free hand," that is vertical, is not the position of maximum reactivity control. The mechanical stop which limits the "in" position of the control arm is protected by a locked cover, the key of which is held in the control room and interlocked with the current supply to the electro-magnetic link. Removal of the key causes all six controllers to "trip" and shut down the reactor. Should removal of the controller be necessary, the stop can then be removed and the control arm placed in the vertical (removal) position, to be withdrawn into a heavy shielded flask placed over the hole in the top shield. Seals are employed to prevent the escape of helium from the reactor during removal operations.

The helium blanket covering the surface of the heavy water is prevented from escaping past the moving parts by means of a long stainless-steel flexible bellows assembly, sealed to the connecting rod and the fixed plug portion. Iron-shot concrete shielding is employed to fill the spaces in the plug portion.

REGULATION AND SAFETY GROUPS

The function of the regulating group is to provide a means of maintaining a steady power level, by initiating compensation for reactivity changes occurring within the reactor. It also serves to change the power level when necessary. The system is fast acting and absorbs a limited maximum value of reactivity. Manual or automatic control can be selected at will. The



(*a*) Steel top plate of reactor.
(*b*) Safety control gearbox (system duplicated).
(*c*) Coarse control arm.
(*d*) Fine control rod.
(*e*) Safety control rod.
(*f*) Coarse-control unit (six in system).
(*g*) Top biological shield (part of reactor).
(*h*) Slave gearboxes (coarse control).
(*i*) Coupling shaft.
(*j*) Fine-control gearbox.
(*k*) Coarse control cover.

Fig. 6 Thermal-reactor control system.

group comprises one fine control rod mechanically coupled to its associated drive gearbox and remotely operated from the control room.

The obvious requirement of providing emergency shut down is catered for primarily by the coarse control shut-off group. The less obvious but equally necessary provision of a control absorber " cocked " at all times, even when shut down, is included in the control of the reactor. Prompt shutting down is effected by a group of two rods, known as " safety " rods, having two positions only, that is, in or out of the reactor. This group is released at a " trip " shut down, but must be withdrawn before major changes are made to the built-in reactivity of the system, such as those involved in loading and the change of experimental set-ups.

Various other items in the system including the master control gearbox shown in Fig. 7 are represented in the diagrammatic layout in Fig. 6. The master control gearbox is situated remotely from the remainder of the system and by an arrangement of Selsyn units and magslips relays the signals received from the control desk to the operational assemblies of the control system.

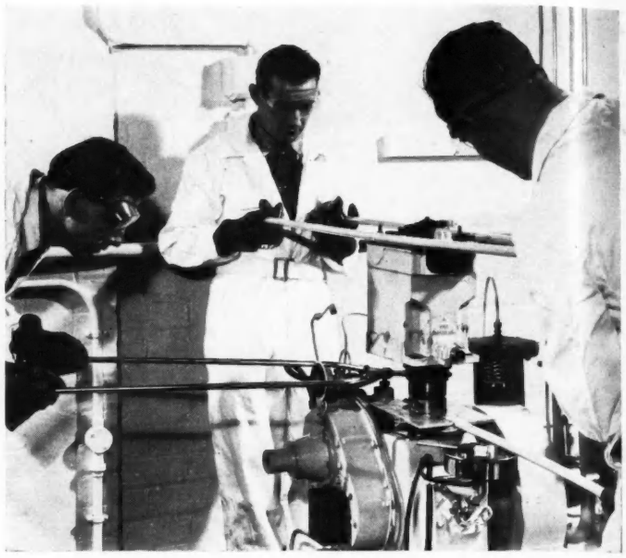


Fig. 8 A cylinder block being fitted over a piston, the top ring of which has been rendered radio-active. From the degree of radio-activity in oil samples taken during the run, the amount of wear products deposited in the oil can be determined.

INVESTIGATING ENGINE WEAR

A film illustrating one of the ways in which atomic energy aids research in the oil industry is to be shown in English, French, Russian, German and Spanish in the Palais des Nations. Entitled " Project 074," the film was made by the Shell Film Unit for the Royal Dutch-Shell Group in conjunction with the Atomic Energy Research Establishment. It includes shots of an atomic pile at Harwell and of the Shell Research Centre at Thornton, Cheshire.

" Project 074 " begins by showing how in testing the wear of a piston ring in a special engine—to assess the wear-reducing properties of different engine lubricating oils—the conventional methods necessitate repeated fitting and removing, as well as precise weighing, of the piston ring under test. Even with all the care taken, results of apparently similar tests may vary considerably, and a number of tests have to be made to obtain an average result. These tests often involve up to 400 hours' running.

The film goes on to describe in detail the newest method in which the piston ring under test is made radioactive in an atomic pile. With all necessary precautions it is then fitted in the test engine. The latter is modified to enable the lubricating oil to be circulated from the sump, while the engine is running, through apparatus which measures degrees of radio-activity. After this the oil returns to the sump as part of the normal circulation. While the engine is running minute particles of iron are worn from the piston ring and pass into the sump oil. As the oil circulates through the radio-activity recorder the amount of radioactivity indicated is exactly proportional to the quantity of iron fragments circulating in the oil. The recorder is sufficiently sensitive to detect one 30-millionth part of an ounce of radio-active iron in the oil. Thus throughout the test it is possible to determine accurately not only the total amount of wear which has taken place since the beginning of the test, but also the rate at which the wear occurs at different periods during the test and under varied conditions. Fig. 8 shows a cylinder block being fitted over a clamped piston, the top ring of which has been rendered radioactive.

MONITORS

Among the exhibits to be shown by General Radiological Limited, 15-18 Clipstone-street, Gt. Portland-street, London, W.1, are a combined beta and gamma ionisation chamber, a flameproof monitor and a portable fast-neutron scintillation monitor. The ionisation chamber, which has been developed under the guidance of the A.E.R.E., is a combination of a re-entrant cylindrical chamber consisting of three concentric brass cylinders and designed for the measurement of gamma-ray emitting isotopes, and a " parallel-plate " form of chamber for measuring beta-ray emitters.

The scintillation monitor is designed to detect fast neutrons in the energy range 0·1 MeV to 20 MeV (1 tolerance of fast neutron represents $\frac{1}{8}$th F.S.D.). An efficiency of 0·7 per cent. is obtained with a Ra-Be neutron source. The phosphor in this instrument is in the form of a sphere and good gamma discrimination is obtained by limiting the thickness. An indication of gamma background is included, and isotropic fluxes may be accurately monitored because of the good 4π response. Cold-cathode circuitry is used throughout, powered by a Ag-Zn lightweight accumulator (35 hours running time). The weight of the unit is 14 lb.

The General Radiological flameproof monitor (type 1300A) is designed to operate in explosive or inflammable atmospheres, and is intended for use as a health monitor for checking the presence and quantity of radioactive contamination on benches, floors and walls. The instrument is sealed and fitted with a dessicator.

The monitor is built into a single unit and housed in a sealed case. Two probes are permanently coupled to it by 12 ft. of pressurised hose, and probe selection is by means of a rotary switch. The output is displayed on a $3\frac{1}{2}$-in. 100 μA meter, and audible indication of count rate is provided by a sealed speaker unit. The probes can be used for either beta, gamma or alpha counting; the beta-gamma probe employs a thin-wall Geiger tube and the alpha probe a photocell-multiplier tube. For operation, air pressure of approximately 5 lb. per square inch is required.

The range switch has six positions, the first two marked 400 volts and 2 kV, and the last four giving full-scale deflections in counts per second of 2,000, 200, 20 and 2. The monitor is mains operated and incorporates a filter unit which lowers spurious responses and RF interference to an acceptable level.

(To be continued)

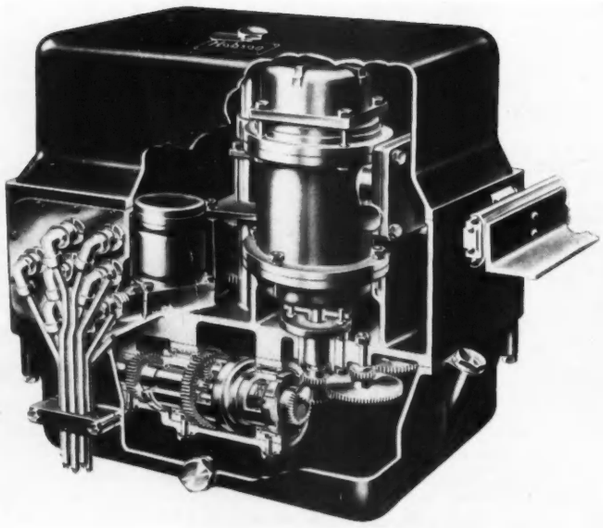


Fig. 7 Situated remotely from the remainder of the system, the master control box relays signals received from the control desk to the operational assemblies of the control system.

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LONDON DESIGN CENTRE

A permanent but changing exhibition of British-made consumer goods, covering a wide range of prices, will be opened by the Council of Industrial Design at 28 Haymarket, London, S.W.1, early next year. Examples of textiles, carpets, pottery, glass, cutlery, furniture, office machinery, garden tools, lighting fittings and heat appliances are among the large variety of products which it is proposed to display.

The new showrooms will be known as the Design Centre for British Industries and will be supported by a trade information service. The Council's photographic and book libraries, its offices and conference room, the offices of *Design* magazine, and the Record of Designers will eventually be located in the same building, but, until further notice, the Council's address will remain at Tilbury House, Petty France, London, S.W.1.

ASPHALT SURFACING ON CONCRETE BASES

2-in. Minimum Recommended

The Asphalt Roads Association, in conjunction with the Cement and Concrete Association, recently carried out an investigation to determine the most suitable design for road construction when employing an asphalt surface on a concrete base. During the course of this investigation a survey was carried out of existing roads surfaced with hot-rolled asphalt in order to compare the performance of varying thicknesses of asphalt on different types of concrete base.

The results of these investigations show that a continuously reinforced concrete slab without expansion or contraction joints is more suitable as a concrete base for hot-rolled asphalt, for the following reasons:

(1) The presence of reinforcement, and the absence of joints in the slab, ensure that there is no relative vertical movement between adjacent points of the slabs which might cause the surfacing to crack;

(2) experience confirms that if the reinforced-concrete base develops cracks these are small and are unlikely to be reproduced in the surfacing;

(3) continuously reinforced concrete is an economical form of construction, as it allows a minimum thickness of concrete to be laid, and delays due to joint construction are eliminated.

It is therefore recommended by the Asphalt Roads Association and the Cement and Concrete Association that the design and construction of a concrete base for asphalt surfacing should follow normal reinforced-concrete road technique. Construction joints should have the reinforcement carried through and, on a poor soil, it may be advisable to include tie bars or extra reinforcement as additional insurance against opening and relative vertical movement. Tie bars should always be provided in longitudinal joints.

The greater the thickness of the asphalt surfacing, the better will be the performance of the base. This is because warping stresses in the concrete due to variation in temperature through the depth of the slab are progressively reduced as the thickness of the surfacing is increased. The possibility that the omission of expansion joints might lead to a compression failure in the concrete base during hot weather has been carefully considered, but if the recommendations given here are adopted the risk is so small that it can be disregarded.

Although satisfactory results have been obtained with asphalt surfacing 1½ in. thick it is recommended that such surfacing should be not less than 2 in. in thickness. When heavy dense traffic is to be expected it is recommended that the asphalt construction should be in two coats: a 2-in. base coat, and a 1½-in. wearing surface, both in accordance with the current edition of B.S. 594.

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METAL-PHASE TRANSFORMATIONS

Symposium

The date of the one-day symposium arranged by the metal physics committee of the Institute of Metals on "The Mechanism of Phase Transformations in Metals" has now been fixed for Wednesday, November 9, 1955. It is understood that the morning session of the symposium will be devoted to transformations which are largely governed by thermal activation (nucleation and growth reactions) and the afternoon session to transformations in which thermal activation is less important, such as martensitic reactions.

The meeting will be held in London and further particulars may be obtained from the secretary, the Institute of Metals, 4 Grosvenor-gardens, London, S.W.1. Telephone: SLOane 6233.

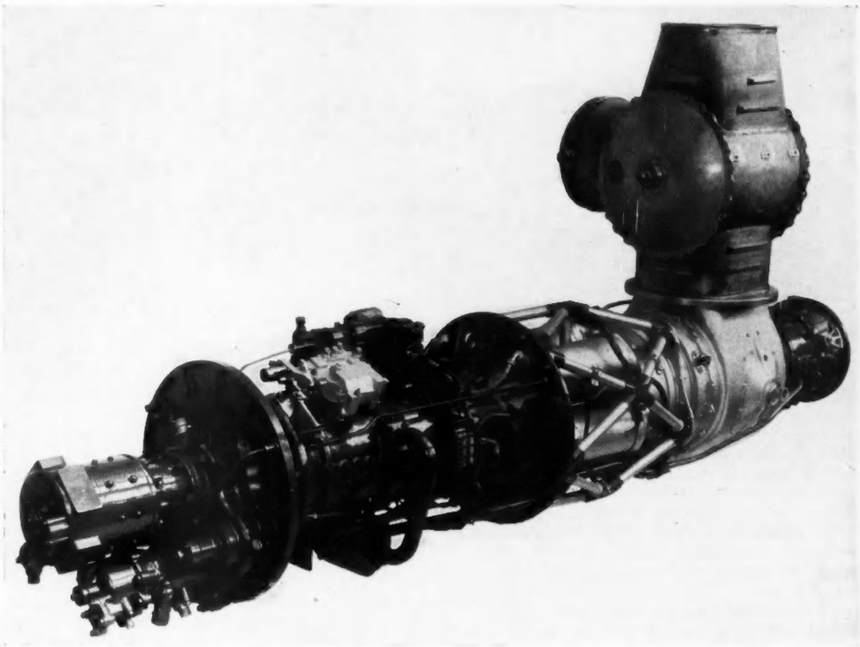

Fig. 1 In the Napier Oryx single-shaft turbo-gas generator for helicopter-rotor reaction drive, the exhaust gases are ducted from the turbine to the rotor head and thence through the blades to the tips, where they are ejected to atmosphere tangentially.

"ORYX" TURBINE GAS-GENERATOR

TIP JET REACTION DRIVE FOR HELICOPTER ROTOR

The Napier Oryx turbo-gas-generator is a single-shaft gas turbine designed primarily for use in helicopters where the rotor is propelled by jet reaction at the rotor blade tips. In this system gas is carried from the generator to the rotor hub and thence through ducts in the blades to the blade tips, where it is ejected to atmosphere tangentially. The absence of reduction gearing and shaft transmission permits a considerable saving in weight and, the manufacturers claim, improves the mechanical reliability and reduces maintenance costs. The Napier engine, which employs an unusual arrangement of main and secondary compressors, benefits in handling and performance from compressor characteristics in which the optimum efficiencies are well removed from surge. The Oryx, which has achieved its design performance and completed 1,400 hours of test-bed running, is shortly to be installed in the Hunting-Percival P.74 helicopter. By the end of 1955 a type test to the standard rating of 750 gas horse-power will be attempted, and preliminary development at 825 gas horse-power begun. Its makers, D. Napier and Son, Limited, Acton, London, W.3, anticipate that the engine will be developed to 900 gas horse-power by the end of 1956.

AIR INTAKE AND MAIN COMPRESSOR

The Napier Oryx engine (Fig. 1), which is a turbo-gas-generator of the single-shaft type, comprises a twelve-stage axial-flow main compressor, five combustion chambers, a two-stage reaction turbine and a four-stage axial-flow auxiliary compressor. A longitudinal section through the engine is shown in Fig. 3. The air from the auxiliary compressor enters a volute in a collector, into which the turbine also exhausts through a separate volute. The air and gas are delivered from a flange on the collector to a two-position non-throttling valve which diverts the mixture either to the free exhaust or to the rotor head as required. Control of the engine is effected through an interconnected fuel metering unit operated by a single lever, and automatic compensation is provided for changes in ambient pressure and temperature conditions.

Fig. 4, on page 180, shows the main compressor intake, compressor half-casing, and support plate. Air is delivered to the main compressor through a radial intake which is cast in RZ5 magnesium-zirconium light alloy. The intake has been designed to suit a plenum-chamber installation and, in consequence, no provision has been made for protection of the intake against icing or debris. In common with all other gas passages, the intake was flow tested

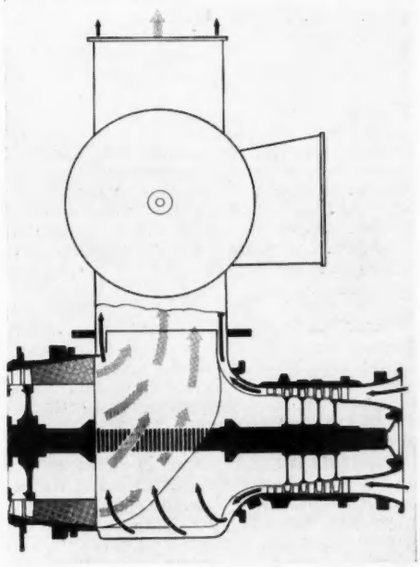

Fig. 2 Collector and diversion valve. The collector, which leads the hot gases to the rotor head, is arranged so that cool air from the auxiliary compressor insulates the hot gases from the diversion valve and duct casing.

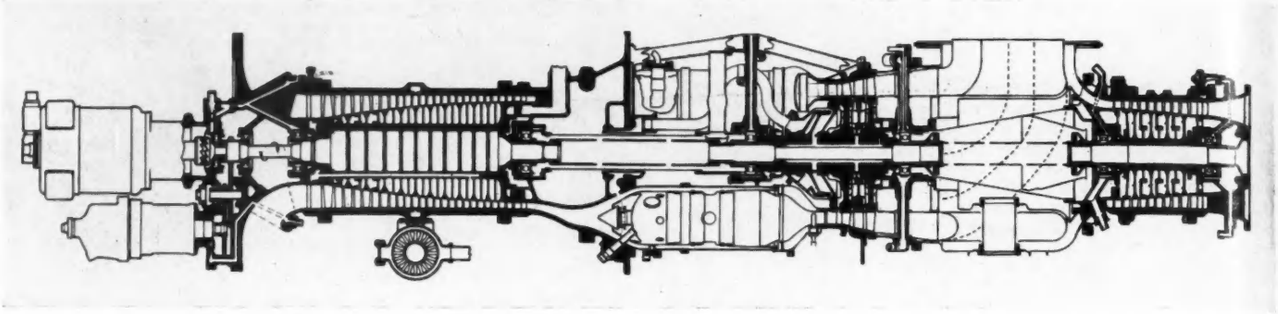

Fig. 3 Longitudinal section through the Oryx. The auxiliary compressor can be seen on the right.

and developed for maximum efficiency and uniform distribution at compressor intake, before incorporation in the final design. Mounted on the front of the main compressor intake are various engine accessories comprising the fuel pump, oil pressure and scavenge pumps, tachometer generator and electric starter.

The twelve-stage main compressor, employing axial flow, has been designed for a mass flow of 9·9 lb. per second and a pressure ratio of 6 to 1 at 21,900 r.p.m. The rotor is of through-bolted disc construction, so providing an "effective" large-diameter shaft, although no actual main shaft exists. Aluminium-bronze blades of Hidurax 1/12A (DTD 197/A) are used throughout, and all the rotor blades are secured by fir-tree roots to the compressor discs which are of S.62 steel for stages 1 to 11 and S.82 steel for stage 12. The stators, which are of shrouded construction for the first three stages and cantilever for the remainder, are contained in the two halves of the RZ5 magnesium-zirconium light-alloy compressor casing.

The complete rotor assembly is supported by a roller bearing at the inlet end, and the outlet bearing is a ball bearing housed in the main support plate. A muff coupling shaft connects the main compressor shaft to the turbine shaft. The rear compressor bearing and the front turbine bearing compartments are connected by a single drainage sump, and this ensures that the muff coupling shaft serrations are well lubricated by oil mist.

The compressor characteristics are such that optimum efficiencies on the engine operating line are well separated from surge, thus permitting good handling qualities without loss of efficiency in normal operation. The margin from surge is further increased at low engine speeds by the use of variable inlet guide vanes controlled by a speed-sensing servo-unit.

The main-compressor support plate, a casting in DTD 708 light alloy, is situated at the rear of the compressor. It includes the diffuser, between the compressor and combustion chambers, and an internally cast annulus into which air is bled from the diffuser for turbine cooling purposes. Provision is made for mounting the engine from four pads, two on the main support and two on the collector casing.

UPSTREAM INJECTION BURNERS

The combustion system, designed by the Napier Company in conjunction with Joseph Lucas, Limited, comprises five tubular chambers with upstream injection burners. (Fig. 5.) Each burner may be removed separately for inspection, without the need for dismantling any other of the engine parts.

Outer casings are fabricated in S.84 material and the flame tubes in DTD 703. The Royal Aircraft Establishment high-energy spark ignition equipment made by the British Thomson-Houston Company, Limited, or Rotax Limited, is fitted for starting. Ignition plugs are provided in two of the combustion chambers from which the flame is propagated to the remainder by interconnectors. The use of upstream injection burners not only reduces the overall length of the system but also gives good combustion at very high air/fuel ratios. Spherical joints are included in the outer casting to allow for slight misalignment on assembly. The engine operates satisfactorily irrespective of whether kerosine or wide-cut fuels are used.

TWO-STAGE REACTION TURBINE

A two-stage reaction turbine with an expansion ratio of 3·14 to 1 has been designed for the Oryx engine. It operates against high back pressure since the exhaust gas mixes with delivery air from the auxiliary compressor; the leaving velocity and swirl are such that the diffusion required before the volute in the collector is small.

The turbine (Fig. 5) comprises two separate bladed rotor discs mounted on a shaft and carried in a fabricated casing which contains the two nozzle assemblies. Of Napier specification DNS 116 steel, the rotor discs are mounted over flank fitting splines on the turbine shaft which is supported at the front by a roller bearing and at the rear by a ball bearing. The drive is imparted to the main compressor by a serrated muff coupling shaft and to the auxiliary compressor by a gear-type coupling shaft.

The rotor blades, which are of Nimonic 90 in stage one and Nimonic 80A in stage two, are attached to the discs by fir-tree roots. The blades are so fitted in the discs that a limited amount of tip rock is obtained, so allowing for the differential expansion of the blades and discs. This relieves the root stresses and ensures a large measure of vibration damping.

The first-stage nozzle blades are secured by inner and outer rings, which are fixed to the casing so that they are free to expand radially. Second-stage nozzle blades have inner and outer platforms and are bolted to the external casing; both stages of nozzle blades are cast in X40 material. An inter-stage seal plate, carrying a seal at the inner diameter and cooling scrolls on each face, is mounted from the nozzle ring by swinging links attached to several of the blade roots. This arrangement allows for differential expansion and ensures concentricity of the seal under operating conditions.

OPPOSED FLOW FROM AUXILIARY COMPRESSOR

A four-stage axial-flow auxiliary compressor is mounted at the rear of the engine on a common shaft, with the air flowing in the opposite direction to that through the turbo-compressor unit.

Designed for a pressure ratio of 1·8 to 1 and an air mass flow of 5·1 lb. per second at maximum rotational speed, the auxiliary compressor is of the conventional shaft and disc type. The whole rotor assembly, including the balance piston and seals, is mounted on a splined shaft and is clamped together by means of ring nuts. The shaft is carried in two bearings, a ball bearing at the inlet and a roller bearing at the outlet end. The turbine outlet bearing and the auxiliary compressor outlet bearing have common chambers, to ensure oil-mist lubrication of the gears on the coupling shaft.

All the blading is of aluminium-bronze, Hidurax 1/12A (DTD 197A) and the rotor blades are fixed to the aluminium discs by fir-tree roots. Each of the four stator stages are shrouded and bolted in the two halves of the RZ5 light-alloy casing. The inlet guide vanes can be adjusted and set for matching purposes but are not variable while the engine is running. The guide

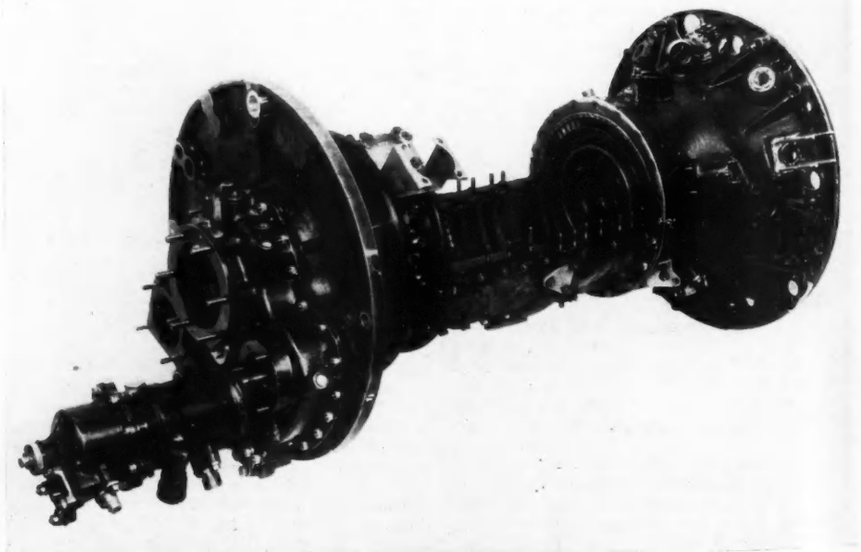

Fig. 4 The main compressor intake, compressor half-casing and support plate. Accessories are mounted on the front of the intake casting.

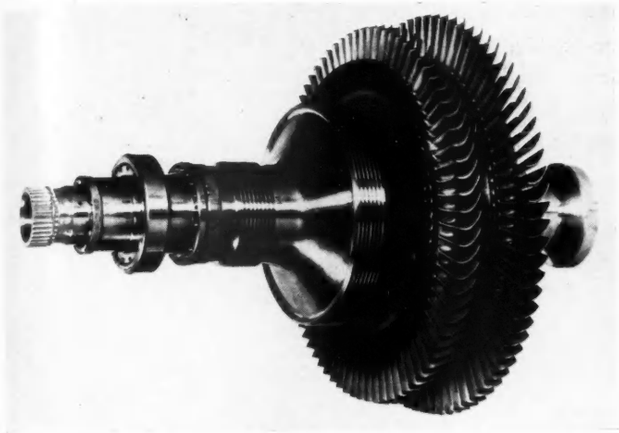

Fig. 5 Two-stage turbine rotor assembly. The blades are so fitted in the discs that a limited amount of tip rock provides for differential expansion.

Fig. 6 The combustion system comprises five tubular chambers fitted with upstream burners.

vanes are mounted in the annular intake which is a RZ5 light-alloy casting.

COLLECTOR AND DIVERSION VALVE

Situated between the turbine outlet flange and the auxiliary compressor delivery, the collector has a single outlet, square in section, through which the turbine exhaust gas and auxiliary-compressor delivery air pass, unmixed, to the two-way non-throttling valve (Fig. 2). Fabricated in DTD 703 steel sheet the collector (Fig. 7) contains two separate volutes, one for the gas and one for the air, which turn the flows normal to their original directions. The internal baffling is so arranged that the compressor air surrounds the exhaust gases and thereby keeps the outer casing cool. The outer layer of relatively cool air persists through the non-throttling valve, and the resultant lower casing temperatures ensure satisfactory operation of the valve and reduce the metal temperature of the duct to the rotor head.

The purpose of the two-position non-throttling valve illustrated in Fig. 9 is to direct the gases during the starting cycle to a nozzle which exhausts to atmosphere, and to divert the gases from the starting nozzle to the rotor head when normal engine operating speeds have been reached. Starting is also facilitated by a butterfly valve in the starting nozzle which has the effect of providing a variable-area nozzle. The non-throttling valve is operated by an oil servo-unit. This unit also is in DTD 703 sheet.

A piston-ring seal-type expansion joint is situated between the collector delivery flange and the two-way valve since, when the engine is installed, the valve is attached to the aircraft structure.

Fig. 7 The collector, in fabricated sheet steel, contains separate volutes for the turbine exhaust gas and auxiliary cooling air.

COOLING, BALANCING AND SEALING

Air is bled from the main compressor to cool the turbine rotor discs, to supply air to the turbine and compressor balance pistons and to pressurise the bearing seals (with the exception of the main compressor inlet bearing). The air to cool the turbine discs and supply the turbine balance piston is tapped from the diffuser after the main compressor, passes into an annulus in the main support plate, and finally enters the turbine through two pipes. From the collecting annulus in the turbine the air flows to the balance-piston chamber, and is then divided, a proportion passing through a seal and up the front face of the stage-one disc, and the remainder into the hollow shaft and to the other disc faces. In passing up the disc faces the air flows through scrolls attached to the seal plate; these scrolls have the effect of lengthening the path of the air and thus enhancing the cooling effect.

To pressurise the bearing seals, air is taken externally through a pipe and filter from stage six of the main compressor. Tappings from the pipe running on the outside of the engine are made at the appropriate places to supply each bearing. Spill air from the bearing seals is allowed to escape through the hollow auxiliary compressor shaft where all oil vapour which may be contained in the air is centrifuged out and therefore retained in the engine.

Rotor-head cooling air is also taken from this source and passes to the rotor head through a non-return valve which is of unbalanced butterfly pattern. The non-return valve is necessary to prevent a reversal of flow in the event of one engine being stopped in a multi-engined installation. From stage 9 of the compressor a further tapping is made which passes forward internally through a hole in the discs, similar to the bolt holes, to pressurise the main-compressor balance chamber at the compressor inlet.

POWERED ACCESSORIES AND CONTROL

The engine accessories are mounted on the front of the main-compressor inlet casing and are driven through a gearbox and quill shaft by the compressor shaft. The accessories comprise a fuel pump, a combined oil pressure pump and three-bank scavenge pump, and a tacho-generator. A drive is also provided for an engine synchronisation unit. A Rotax electric starter, also situated in front of the main compressor, is mounted co-axially with the compressor and provides a direct drive on to the compressor shaft.

Control of the engine is effected by a single lever operating a Napier fuel metering unit which automatically compensates for changes in ambient pressure and temperature conditions. It also includes an overspeed governor and a fixed-datum turbine inlet temperature control. Fuel is supplied by a Lucas fixed-stroke plunger pump. An inlet guide vane control which is responsive to changes in the engine speed is also fitted.

Control of the starting butterfly valve and the two-position non-throttling valve is manual. In the case of a twin-engine installation, in which both engines deliver to a common duct, the manual control of the two-position valve may be overridden by a speed-sensing unit, in the case of the engines not running at synchronised speed.

Full advantage of the compressor characteristics has been taken in the design of the controls, and the engine has a rapid surge-free acceleration. The control system also embodies devices giving instantaneous protection in emergencies that might occur in either single or multi-engine applications.

Dry-sump lubrication is used and the necessary oil cooler and oil tank are installational items. The rotary positive-displacement pressure pump delivers oil at 150 lb. per square inch, which is restricted to maintain an engine oil pressure of 80 lb. per square inch and a pressure of 135 lb. per square inch in the non-throttling valve servo-mechanism reservoir. An oil filter is contained within the pump housing. Each of the pumps comprising the three-bank scavenge pump is divided into two, thus independent scavenging

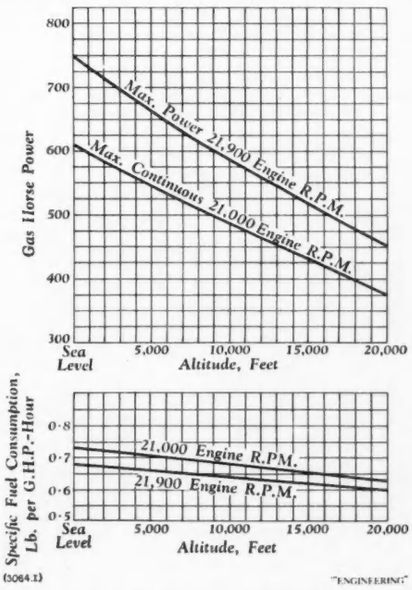

Fig. 8 Variation of horse-power and fuel consumption with altitude.

Fig. 9 The two-way non-throttling valve directs the exhaust gases to atmosphere for starting.

is obtained for each of the six main engine bearings.

PERFORMANCE

The maximum speed of the engine is 21,900 r.p.m. and the direction of rotation, viewed from the rear of the turbo-compressor unit, is anti-clockwise. The maximum diameter, excluding the collector is 19¼ in. and the overall length excluding accessories is approximately 83½ in. The unit's net dry weight excluding all parts beyond the gas-collector delivery flange, is 495 lb., and the non-throttling valve and expansion joint weight 60½ lb. The gas flow under take-off conditions is 14·4 lb. per second. Suitable fuels are aviation turbine fuel (D.E.R.D. 2482) and wide-cut gasoline (D.E.R.D. 2486), and for lubricating oil synthetic (D.E.R.D. 2487) is recommended. The oil consumption at maximum continuous speed is 1 pint per hour.

All performance figures, which are given in the table below, are quoted for the international standard atmosphere. The engine has been designed to suit a plenum-chamber installation for each compressor, and it is assumed that side intakes are fitted to the plenum chambers; the performance figures are therefore given for static conditions only.

The output expressed in terms of gas horse-power is based on the isentropic temperature drop for the total head to static expansion ratio available at the jet-pipe nozzle after the non-throttling valve, and is equivalent to the shaft

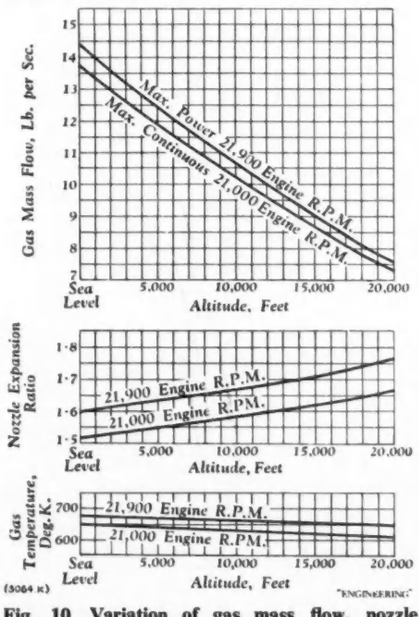

Fig. 10 Variation of gas mass flow, nozzle expansion ratio, and gas temperature with altitude.

Performance Figures for Napier "Oryx" Turbo-Gas Generator.

Altitude (ft.)	Engine speed (r.p.m.)	Gas mass flow (lb. per sec.)	Expansion ratio	Gas temperature (deg. K.)	Output (gas horse-power)	Specific fuel consumption (lb. per gas h.p.-hour)
			(i) *Maximum power*			
SL ..	21,900	14·40	1·600	678	750	0·680
6,000	21,900	12·10	1·642	668	645	0·657
			(ii) *Maximum continuous*			
SL ..	21,000	13·75	1·515	650	610	0·735
6,000	21,000	11·55	1·557	637	530	0·703

power that would be developed if the gases were used to drive a turbine having 100 per cent. efficiency. The performance quoted is for the engine only and not for the engine-rotor combination in helicopter application. Further details of engine performance are shown by the curves in Figs. 8 and 10.

* * *

LAUNCHES AND TRIAL TRIPS

M.S. "CLIFFORD J. ROGERS."—Single-screw cargo vessel, built by Canadian Vickers, Ltd., Montreal, to the order of the British Yukon Ocean Services Ltd., Vancouver, for service between Vancouver and Skagway, Alaska. Fitted with removable bulkheads to facilitate quick conversion into a bulk-cargo carrier. Main dimensions: 336 ft. overall by 47 ft. by 25 ft. 6 in. to upper deck; deadweight capacity, 4,000 tons. Two eight-cylinder in-line oil engines each developing 995 b.h.p. at 800 r.p.m in service and driving a single screw through a Hindmarch-Modern Wheel Drive reverse-reduction gearbox. Engines constructed by Mirrlees, Bickerton and Day, Ltd., Stockport, Cheshire. Service speed, 14 knots. Launch, early July.

M.S. "KESTREL."—Single-screw tug, built by J. Samuel White & Co., Ltd., Cowes, Isle of Wight, for J. P. Knight, Ltd., London, E.C.3. Main dimensions: 101 ft. 8 in. by 28 ft. by 13 ft. 9 in. Eight-cylinder Diesel engine, developing 1,150 b.h.p., constructed by British Polar Engines Ltd., Glasgow. Launch, July 6.

M.S. "SHELL FARMER."—Singie-screw oil tanker, built by Cook, Welton and Gemmell, Ltd., Beverley, Yorkshire, for Shell-Mex and B.P., Ltd., London, W.C.2. Main dimensions: 145 ft. by 29 ft. by 8 ft. 6 in.; deadweight capacity, about 450 tons. Diesel propelling machinery with Voith-Schneider propeller installed. Launch, July 8.

S.S. "MASTER GEORGE."—Single-screw cargo vessel, built and engined by John Readhead and Sons, Ltd., South Shields, to the order of Mr. N. G. Nicolaou, Monte Carlo (Agents: George Nicolaou, Ltd., London, E.C.3), for Miralago Compania Armadora S.A., Panama City, Panama. Main dimensions: 441 ft. 3 in. between perpendiculars by 61 ft. by 39 ft. 3 in. to upper deck; deadweight capacity, about 11,860 tons on a draught of 28 ft. 1 in. Triple-expansion steam reciprocating engine, working in conjunction with a Bauer-Wach low-pressure exhaust turbine. Steam supplied by three oil-fired boilers. Service speed about 13 knots, but, on the trials, a mean speed of 14·46 knots was obtained. Trial trip, July 19.

M.S. "BORDER SENTINEL."—Single-screw oil tanker, built and engined by Swan, Hunter, and Wigham Richardson, Ltd., Newcastle-upon-Tyne, for the Lowland Tanker Co., Ltd., London (Managers: Common Brothers, Ltd., Newcastle-upon-Tyne). Main dimensions: 515 ft. between perpendiculars by 69 ft. 6 in. by 37 ft. 6 in.; deadweight capacity, about 16,000 tons on a summer draught of about 30 ft. Swan Hunter-Doxford six-cylinder opposed-piston oil engine, developing 6,400 b.h.p. at 115 r.p.m. in service. Speed, 13¾ knots in service. Launch, July 19.

M.S. "ESPEN."—Single-screw cargo vessel, built by Short Brothers, Ltd., Sunderland, for Mr. Bj. Ruud-Pedersen, Oslo, Norway. Main dimensions: 450 ft. between perpendiculars by 61 ft. by 38 ft. 8 in. to shelter deck; deadweight capacity, about 10,000 tons on a mean summer draught of 26 ft. 6 in. Kincaid-Harland and Wolff-Burmeister and Wain five-cylinder single-acting two-stroke Diesel engine, developing 5,500 b.h.p. at 110 r.p.m. Engine arranged to burn heavy-fuel oil. Launch, July 19.

M.S. "WYRE DEFENCE."—Single-screw trawler, built by Cochrane and Sons, Ltd., Selby, Yorkshire, for Wyre Trawlers, Ltd. (Managers: Merchants (Fleetwood), Ltd.), Fleetwood, Lancashire. Main dimensions: 127 ft. 6 in. between perpendiculars by 27 ft. by 13 ft. 6 in.; gross tonnage, about 340. Seven-cylinder direct-reversing Diesel engine, developing 736 b.h.p. at 235 r.p.m. in service, constructed by Mirrlees, Bickerton and Day, Ltd., Stockport, Cheshire, and installed by Charles D. Holmes & Co., Ltd., Hull. Launch, July 21.

M.S. "OREGIS."—Single-screw ore-carrying vessel, built by William Gray & Co., Ltd., West Hartlepool, for Ore Carriers, Ltd., London, E.C.3. Fifth vessel of an order for six. Main dimensions: 407 ft. between perpendiculars by 57 ft. by 33 ft. 4 in.; deadweight capacity, about 9,000 tons on a draught of 25 ft. 6 in. Hawthorn-Doxford five-cylinder Diesel engine, constructed by Hawthorn Leslie (Engineers), Ltd., Newcastle-upon-Tyne, and installed by the shipbuilders. Service speed, 12 knots. Launch, July 21.

M.S. "SANDRINGHAM QUEEN."—Single-screw cargo vessel, built by the Goole Shipbuilding and Repairing Co., Ltd., Goole, Yorkshire, for Queenship Navigation, Ltd., London, E.C.3. Main dimensions: 220 ft. by 35 ft. 6 in. by 15 ft. 6 in.; deadweight capacity, about 1,640 tons. Seven-cylinder Diesel engine, developing 1,120 b.h.p. at 250 r.p.m., constructed by British Polar Engines, Ltd., Glasgow. Launch, July 21.

M.S. "D.19."—Single-screw off-shore dredger, built and engined by the Chantiers et Ateliers Augustin Normand, Le Havre, France, for the French Navy. Main dimensions: 151 ft. 11 in. by 27 ft. 11 in. by about 7 ft. 5 in.; displacement, 397 tons. Second vessel of a series of six. Double-reduction geared steam turbine developing 1,800 h.p. Speed, 15 knots. Launch, July 21.

S.S. "SAN FABIAN."—Single-screw oil tanker, built by Smith's Dock Co., Ltd., South Bank-on-Tees, for the Eagle Tanker Co., Ltd., Nassau, Bahamas. First vessel of an order for two. Main dimensions: 530 ft. between perpendiculars by 69 ft. 3 in. by 39 ft.; deadweight capacity, about 18,000 tons on a draught of 29 ft. 6 in. Double-reduction geared steam turbine constructed by Hawthorn Leslie (Engineers), Ltd., Newcastle-upon-Tyne. Steam supplied by two Foster Wheeler oil-fired boilers. Service speed, 14½ knots. Launch, July 21.

M.S. "ST. CHAD."—Single-screw trawler, built by Cook, Welton and Gemmell, Ltd., Beverley, Yorkshire, to the joint order of St. Andrew's Steam Fishing Co., Ltd., Hull, and F. and T. Ross, Ltd., Hull. First of a series of three for these owners. Main dimensions: 180 ft. overall by 30 ft. by 15 ft. 3 in.; fishroom capacity, about 14,700 cub. ft. Propulsion by an eight-cylinder Diesel engine, developing 1,050 b.h.p. at 250 r.p.m., constructed by Mirrlees, Bickerton and Day, Ltd., Stockport, Cheshire, and installed by Amos and Smith, Ltd., Hull. Launch, July 22.

S.S. "BEARWOOD."—Single-screw collier, built by Austin and Pickersgill, Ltd., Sunderland, for William France, Fenwick & Co., Ltd., London, E.C.3. Main dimensions; 344 ft. overall by 46 ft. 3 in. by 22 ft. 4 in. to upper deck; deadweight capacity, 4,600 tons on a mean summer draught of 20 ft. Direct-acting triple-expansion steam engine of reheat design, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Sunderland. Steam supplied by two oil-burning boilers. Speed on trial, 11¼ knots fully loaded. Trial trip, July 23.

A T-ended launder is used to deliver molten metal to two strands simultaneously on the Sheppard pig-casting machine.

MACHINE CASTING OF ELECTRICALLY SMELTED IRON

TWO-STRAND MACHINE FOR ITALY

Electrically-smelted iron is cast at a higher temperature than is usual with blast-furnace iron, and because of its extreme fluidity it may be difficult to handle. The machine illustrated herewith has been designed and built by Sheppard and Sons, Limited, Bridgend, Glamorganshire, for Nazionale Cogne, Aosta, Italy, to deal primarily with the output from three Lubatti 3,500-kVA electric smelting furnaces, but it also has to handle the iron from two blast furnaces at week ends. The Lubatti furnaces produce a total of 150 tons of iron every 24 hours, and the blast-furnace output is 500 tons in the same period. During the week the blast-furnace iron is absorbed in the Bessemer plant, but on Sundays it is cast to pig; the quantity dealt with by the Sheppard casting machine is therefore 150 tons a day on week days and 450 to 500 tons on Sundays. The iron is cast into the form of pigs or ingots of the three-hump type, 600 mm. long and 150 mm. wide.

The machine is of the two-strand type, the strands being independently driven but identical in design and carried side-by-side in the same fabricated steel structure. Hot metal is poured from a crane ladle to a T-ended launder which distributes the metal equally between the two casting strands. The moulds, which are of hematite iron, are carried on specially-designed chains, with flanged rollers running on inclined tracks, the incline rising from the pouring to the discharge end. There are 120 moulds at any one time on the top of the strand. The strands are driven from the discharge end, the drums at the pouring end being used for tension purposes. The drive to each strand is from an electric motor of the four-speed pole-change type, of 7½ h.p., and designed for the local 380-volt, 3-phase, 50-cycles current. Control of the motors is from a panel adjacent to the machine, with two sets of push-buttons, one for each motor, which are marked with the figures 1,500, 1,000, 750 and 500 to represent the available motor speeds in r.p.m. Stop buttons are also provided on the panel, which houses the contactors and overload protection gear. The drive is taken from the motors to the driving drums through slip couplings, worm gearboxes, and spur gears.

WATER COOLING

Approximately one third of each strand is equipped with pipes and spray nozzles for spraying cold water on the metal in the moulds, the water being pumped from a nearby stream at 3,000 to 4,000 gallons an hour. Used water is collected in a drain tray below the moulds and returned by gravity to the stream. The ingots, which are already solid soon after leaving the pouring point, are thus cooled sufficiently to allow them to be discharged by gravity at the upper ends of the strands. At this point they fall into chutes leading to a concrete-lined pit, from which they are removed by a magnet crane as required.

The moulds are still warm after the ingots have been discharged and immediately after turning round the drive drums at the discharge end they are sprayed with a mould preparation liquid consisting of hydrated lime and water. The liquid is pumped from a storage tank and distributed to the moulds by a system of pipes and spray nozzles underneath the strands. The heat of the moulds is sufficient to dry the mixture before the casting end is reached. Surplus liquid falls into a drain tray from which it returns to the storage tank. Because the lime mixture tends to settle it is necessary to provide a means of agitation in the tank. This is done by a cast-iron propeller mounted near the bottom of the tank and carried on a vertical spindle in a tubular casing. An electric motor, carried on a bracket on the tank top, drives the spindle through V-belts and pulleys. The propeller creates a downwards current by which the liquid is drawn through a weir in the tubular casing, down inside the casing itself, and thrown against a renewable wearing plate on the tank bottom. The entire contents of the tank are thus kept in constant movement. Both strands are served by the one pump and agitator unit, which is controlled from a push-button panel near the machine. Stop valves are provided so that either strand can be isolated from the spray gear if required.

ONE MAN OPERATION

The hot metal is brought to the machine in a ladle by overhead crane, and the ladle is tilted by the crane driver. Only one operator is needed to run the casting machine. He has three sets of controls, covering the strand speeds, pump and agitator and cooling water supply. The ingots are self-discharging, and no attention from the operator is required at this end of the machine.

In operation the machine is set to suit conditions caused by the intermittent arrival of hot metal. In any smelting process, particularly where several furnaces are involved, the times at which metal will be available are bound to vary, and if the machine has been standing for a comparatively long period, the moulds will be cold. When this is so it will be possible to run the strands at a higher speed than if the machine had just made a cast and the moulds were hot. The four motor speeds give suitable mould travel times for the operator to set the machine in accordance with the conditions ruling at any time. Cooling water flow can be adjusted to suit the metal. Mould spray and agitator gear, once set in operation, require no further attention while casting is in progress.

The two strands are identical and are provided with separate drives and controls.

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PUBLIC HEALTH ENGINEERS

The style and title of the Institution of Sanitary Engineers, 118 Victoria-street, London, S.W.1, which was incorporated in 1916, has now been changed to "The Institution of Public Health Engineers".

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INDEX TO "ENGINEERING"

Volume 178 now ready

The Index to Volume 178 (July-December, 1954) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher, 35 and 36 Bedford-street, London, W.C.2. Any reader wishing to receive regular copies of the Index as they are published can apply to be put on the mailing list. Those already on the mailing list need not re-apply.

FATIGUE BENDING-TEST MACHINE FOR ELECTRIC CABLES

When a power cable is loaded with a heavy current its temperature rises and its length is increased. To accommodate this increase it is usual to provide a loop in the manholes and, as the load varies, this may experience up to 10,000 bending cycles during a lifetime of 20 years. To assess the effects of this repeated flexing on the cable and to compare the fatigue properties of different sheath materials, Pirelli-General Cable Works, Limited—an Associate Company of the General Electric Company, Limited, Kingsway, London, W.C.2—have designed a bending-test machine, to simulate the movements due to heat which occur under service conditions.

DETAILS OF DESIGN

The framework of this machine, which is illustrated in Fig. 1, is made up of welded mild-steel angle sections and is designed so that the loads are taken by the front vertical members and the short cross members. Its width is as small as possible to ensure rigidity and so that a bank of machines may be installed in the minimum space.

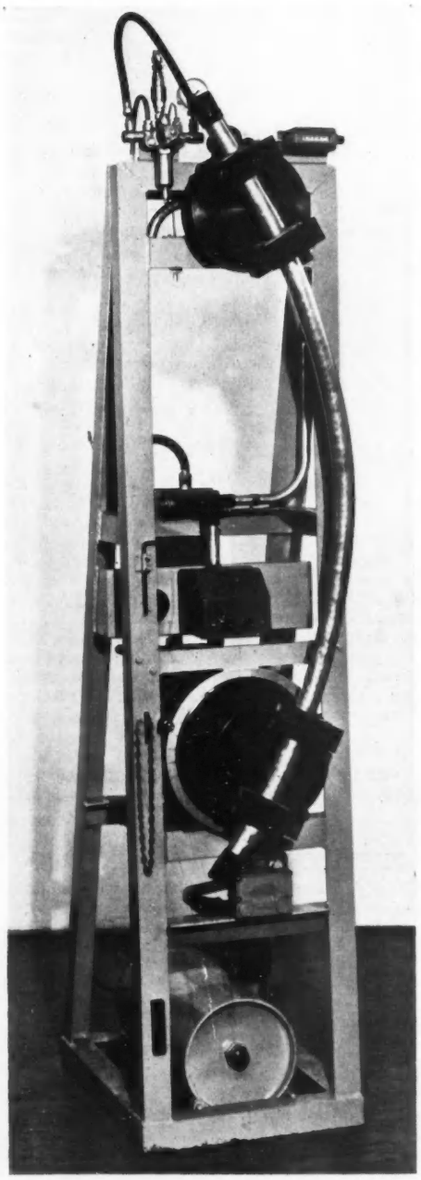

Fig. 1 The fatigue bending-test machine for electric cables at the Pirelli-General cable works.

Samples of the lead or aluminium-sheathed cable to be tested are cut to a length of about 4 ft. 3 in. and are bent accurately into an arc of 3 ft. radius. They are then secured in the machine by two pairs of clamps. Of these the lower pair is mounted on a steel hub, which contains two 5-in. diameter ball races on an eccentric. Another eccentric is mounted on the output shaft of a gearbox and the two can be connected. Each eccentric has a throw of ¾ in. and by rotating one with respect to the other a total throw of from zero to 1½ in. can be obtained, so as to vary the stress, the cable being free to pivot about the axis of the races. There is a similar pivot without eccentrics at the top of the machine to which the upper end of the test length of cable is fixed and is thus free to turn about a horizontal axis.

The machine is driven by a three-phase motor through integral multiple-stage spur gearing with a strengthened output shaft. The rotation of the eccentric causes the distance between the pivots to vary harmonically, with the result that the cable is flexed at a frequency of 9 cycles per minute.

The ends of the cable are sealed with brass caps containing polyvinyl chloride bushes which are held in compression against the sheath. The upper cap is connected to a compressed-air supply and the system is placed under a pressure of from 10 to 20 lb. per square inch before the test is begun. When failure occurs the resulting drop in pressure caused by the leakage of air through the crack operates a switch and trips the motor starter, the number of cycles received by the specimen being recorded by an electric counter operated by the lower pivot. Once the machine has been set in motion with the specimen in position it can therefore be left to run unattended until failure takes place. The pre-set values can be checked by taking strain gauge measurements at the mid-point of the specimens during the test.

The specimens normally subjected to fatigue bend-testing have a nominal diameter of 1·6 in. Larger or smaller diameters can, however, be employed and in the case of smaller cables two specimens can be accommodated side by side. As the frequency of cyclic flexing has an effect on the number of bends which some materials will withstand, the speed of operation can be varied to examine this effect and the results correlated with those obtained regarding the life.

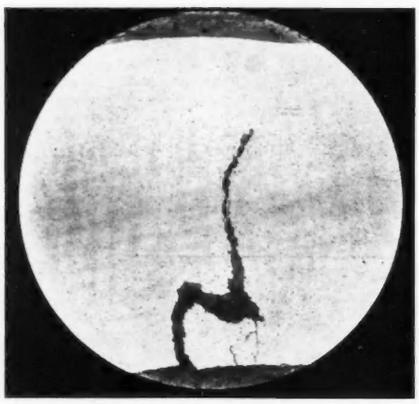

Fig. 2 Photomicrograph of a fatigue crack in an aluminium cable sheath after cyclic flexing in the machine.

OXY-PROPANE FOR INGOT-MOULD HOT-TOPS

Neutral Flame at 5,000 deg. F.

In metallurgical works many methods have been employed for maintaining the upper portion of a metal ingot fluid so as to reduce the contraction cavity or "pipe" on solidification. The greater the cost of the metal involved, the more elaborate are the measures taken to prevent wastage from ingot pipe, and, in the case of stainless and other highly-alloyed steels, considerable attention has always been given to the question of ingot-mould hot-tops.

One method of prolonging fluid conditions in the ingot head is to apply an external source of heat, and a recent development is to use oxy-fuel gas heating for the purpose. Results in this country and in the United States, it is stated, have shown that an improvement of 10 per cent. in ingot yield can be obtained by this procedure. Oxygen-propane has been established as the most suitable gas mixture, the flame produced being neutral to most steels at oxy-fuel-gas ratios of between 3·25 and 4 to 1. The flame temperature is given as 5,000 deg. F. (2,760 deg. C.). It is pointed out that oxygen is available in all works and that propane can be supplied in easily transportable cylinders.

A blowpipe, burning oxygen and propane, applies heat directly to the upper surface of a solidifying ingot and prolongs the fluidity of the metal, thus reducing the contraction cavity.

The equipment required for the process has been developed by the British Oxygen Company, Limited; it is quite simple, consisting merely of a blowpipe with a suitable nozzle head and a quick-acting gas-control valve. As is seen in the illustration above, the blowpipe head is held vertically over the steel surface in such a manner that heat is applied directly to the top of the metal. The exposed portions of the blowpipe are suitably lagged to protect them from the heat radiated from the hot metal.

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CAVITATION PROBLEMS

Symposium at N.P.L.

A symposium devoted to problems connected with cavitation in hydrodynamics is being held at the National Physical Laboratory, Teddington, Middlesex, from Wednesday, September 14, to Saturday, September 17, next. Attendance will be by invitation and interested persons should communicate with the Director of the Laboratory, at the above address, as much in advance as possible. The telephone number of the Laboratory is Molesey 1380.

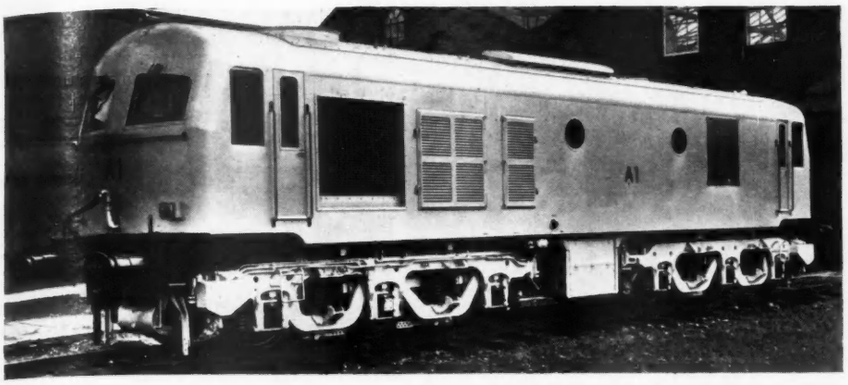


Fig. 1 Of the 94 Diesel-electric locomotives ordered for the Irish Railways, 60 are of the Co-Co type. They have a continuous tractive effort of 17,000 lb.

BROAD-GAUGE DIESEL-ELECTRIC LOCOMOTIVES

1,200-H.P. ENGINES FOR IRELAND

Fuel is one of the problems of Eire and is felt not least on the railways. Economic considerations have led Coras Iompair Eireann to change from steam to Diesel traction, and an order was placed in 1954 with the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, for 94 Diesel-electric locomotives. Of these, 60 were to be 1,200-h.p. Co-Co engines and the remaining 34, 550-h.p. Bo-Bo type. Several of the former have been completed and the first is now running in Eire. It is shown in Fig. 1.

The main dimensions of these locomotives are: gauge, 5 ft. 3 in.; length over buffers, 51 ft.; length between pivot centres of bogies, 26 ft.; bogie axle centres, 5 ft. 6¾ in. for the outer pair of axles and 6 ft. 8¼ in. for the inner pair; wheel diameter, 38 in.; width of body, 8 ft. 10 in.; and weight in working order, 85 tons. Power is supplied by a Crossley eight-cylinder V-engine working on the two-stroke cycle and using exhaust-pulse pressure charging. This engine, the HSTV8, is the same as that used in the class-X locomotives recently supplied by Metropolitan-Vickers to the Western Australian Government Railways, and has a bore and stroke of 10½ in. and 13½ in., respectively. For the present application it is rated at 1,200 h.p. at 625 r.p.m. It drives a Metropolitan-Vickers generator which is bolted directly to it to form a single unit. This unit is mounted on rubber-bushed pins, using three-point suspension.

The generator supplies the six traction motors, each of 250 h.p. maximum rating, each axle of the locomotive being driven. These motors are fitted with large-capacity oil wells to give long service, and have the axle suspension bearings lined with white-metal. The outer ends are suspended from Silentbloc units and a link applies lateral restraint. The tractive effort developed by each motor is 5,350 lb. at a speed of 17·3 m.p.h., and the continuous rating for the locomotive is 17,000 lb.

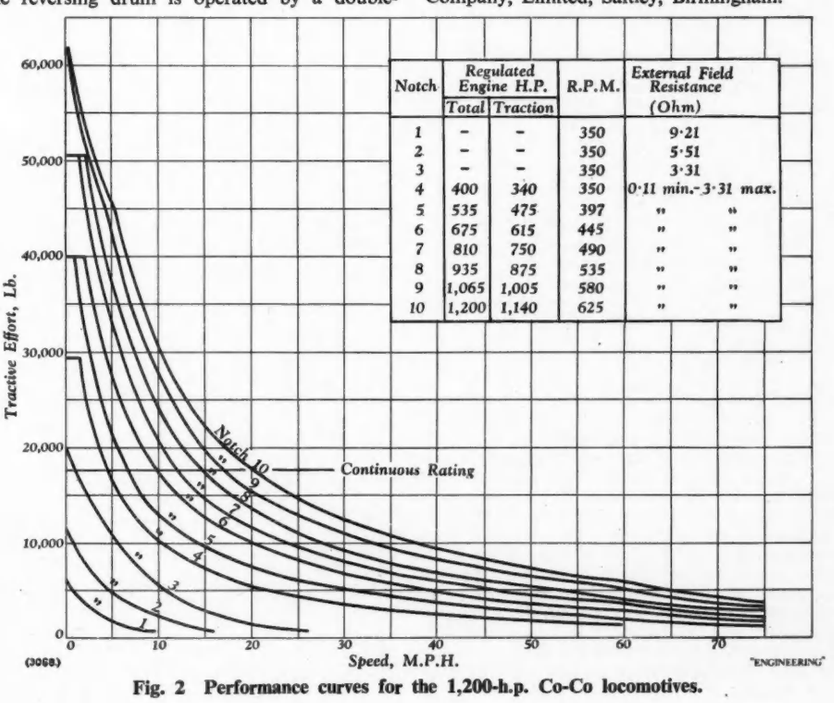
Mounted directly on the main generator shaft is an auxiliary generator, supplying power at 110 volts direct current for such equipment as the brake exhauster, ventilating fan for the forced-draught cooling of generator and motors, engine cooling fan, cab heaters, etc. Also driven from the end of the generator shaft is an air compressor supplying the electro-pneumatic control gear, sanders, whistles and window wipers. In all, this auxiliary load amounts to about 60 h.p., leaving 1,140 h.p. for traction purposes. The Diesel engine is started from lead-acid batteries, using the main generator as the starting motor. The batteries are charged from the auxiliary generator and protected by a cut-out system.

The locomotive body is steel, mounted on a rigid underframe carrying the power equipment, and there is a completely enclosed cab at each end. All controls are duplicated in each cab so that not only can the locomotive be driven from either end but also from either side for convenience in shunting. All controls are arranged for one-man operation. An electro-pneumatic system was adopted owing to the distance apart of the various components and the amount of servo-power that this system can give. The engine governor is controlled through a mechanism operated by four air-cylinders, the pistons of which are joined by links to give different ratios of movement. In this way, very fine adjustment is possible by admitting air to the cylinders separately, while yet allowing considerable movement of the pistons. Similarly, the reversing drum is operated by a double-acting air cylinder through a rack-and-pinion mechanism.

The controllers have 10 notches, of which the first three affect the generator field. Notch 4 brings the auto-regulator into operation which links the engine governor, the fuel supply and the excitation. It is operated by an oil servo-motor. The remaining notches control the engine speed. The various switches and contactors are contained in two cubicles, one for the high-tension gear and one for the low. Indicators are fitted for earth or overload faults as well as for oil and water pressures and temperatures. Performance curves are given in Fig. 2.

For safety, the " dead man " system has been incorporated. When driving normally, this is operated by a pedal arranged for the driver when he is seated (either on the left or right-hand side of the cab). It can also be operated by a push-button which the driver can reach while he is leaning out of the side window for shunting operations. The system is arranged so that releasing the pedal or button operates a warning buzzer immediately, but does not cut off the power and apply the brakes till 5 seconds later. This delay allows the driver to change position when fatigued and also to cross from one side of the cab to the other without stopping the locomotive. Vacuum-operated brakes are fitted for both the locomotive and the train. The Gresham augmented system is used, allowing separate braking of locomotive and train. Two double-ended cylinders are carried on each bogie, each end of each cylinder operating three brake shoes.

The bogies are of Commonwealth design and are of cast steel. The centre H-piece which carries the main pivot is held by four swing links and is removable to give access to the motor driving the centre axle. Double helical springs support forged equalising berams, which are of American type. Monroe shock absorbers are fitted. The axles run in Hoffmann parallel-roller bearings. A " central " lubrication system is used, all the lubricating points being brought out to panels on each side of the bogie, thus allowing periodic lubrication to be carried out quickly and simply. The wheels, supplied by Taylor Brothers and Company, Limited, Trafford Park Steel Works, Manchester, 17, are solid discs made from acid steel. All mechanical parts of the locomotives were made by the Metropolitan-Cammell Carriage and Wagon Company, Limited, Saltley, Birmingham.



Notch	Regulated Engine H.P. Total	Regulated Engine H.P. Traction	R.P.M.	External Field Resistance (Ohm)
1	–	–	350	9·21
2	–	–	350	5·51
3	–	–	350	3·31
4	400	340	350	0·11 min.-3·31 max.
5	535	475	397	" "
6	675	615	445	" "
7	810	750	490	" "
8	935	875	535	" "
9	1,065	1,005	580	" "
10	1,200	1,140	625	" "

Fig. 2 Performance curves for the 1,200-h.p. Co-Co locomotives.

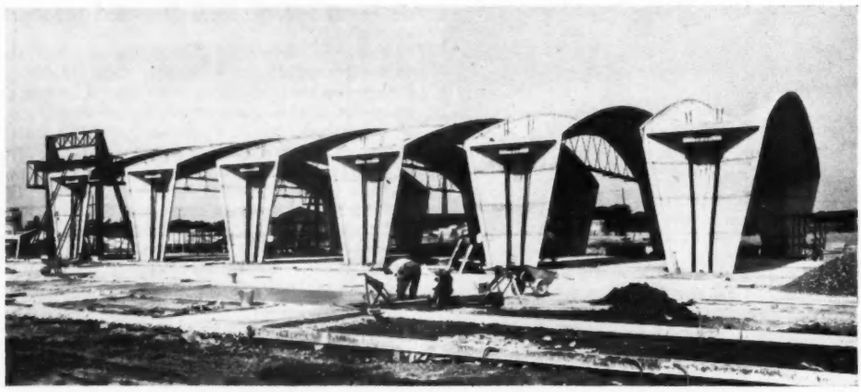


Fig. 1 The new pre-casting shop for Messrs. Matthews and Mumby will be 250 ft. long by 90 ft. clear span. The main frames, tied arches of pre-cast concrete segments, are at 25 ft. centres, and are 15 ft. wide at the springings and across the arch. The roof will be completed by hipped lights and the walls will be glazed, except for a low brick wall, between the columns.

TIED-ARCH FRAMES OF PRE-CAST CONCRETE

WORKSHOPS WITH 90-FT. CLEAR FLOOR WIDTH

A factory for making units of pre-cast concrete, offices and ancillary workshops are being built on a 10-acre site in Oldham-street, Denton, near Manchester, for Matthews and Mumby, reinforced concrete engineers, whose head office is at present at 129 Stockport-road, Manchester, 12. When completed, the accommodation will comprise a main casting shop (which is the principal subject of the following article) 250 ft. long by 90 ft. wide, for making pre-cast floor beams and other relatively small units; a bar-bending shop 150 ft. long by 90 ft. and a mechanics' shop 50 ft. by 90 ft., together in a building similar to the main casting shop; and administrative and design offices. There will also be a joiners' shop and ancillary buildings such as a boiler house, garages and canteen. Uncovered areas on the site will be used for casting and prestressing large members such as bridge beams, and for stacking and curing floor beams.

MAIN PRODUCTION SHOP

Both the casting shop and the single building accommodating the bar-bending and mechanics' shop require uninterrupted floor areas of the largest possible dimensions. Single spans of 90 ft. at 25-ft. centres are being used. After consideration of several methods of achieving this, the most suitable was found to be a series of pre-cast concrete arched frames of V-section tied at the intersections of the arches and the columns. The arch and its supporting column are shown in elevation, together with sections through the columns and the arch, in Fig. 2, and under construction in the other illustrations.

The casting shop is designed to take the greatest possible advantage of mechanisation. There will be 14 casting beds, 150 ft. long, each containing two moulds for floor beams and with provision for prestressing on a long-line system, although it will be possible also to use the beds for normally reinforced beams. About 50 ft. of the remaining length of the shop will be used for non-standard members. Suspended from the roof, and extending the whole length of the shop, will be 14 monorail crane-tracks each placed centrally over a casting bed. These will be used for distributing concrete from a central mixing plant and for carrying the hardened beams from the beds to one end of the shop where they can be placed on trolleys and moved to the curing areas. Provision is to be made for heating the beds to enable a 12-hour cycle to be maintained.

Sand and gravel will be stored in separate ground-level bunkers. After draining and natural drying, the materials will be fed on to a belt conveyor leading to the storage compartments of the bunkers over the automatic batch-weigher. Cement will be stored in high-level circular silos from which it will be drawn by a screw conveyor to the cement weigher and then to an automatically operated pan mixer. Each mixing cycle will be initiated by the passage over a switch of the concrete skip conveying the previous batch to the casting beds, thus ensuring that there will be neither a delay in supplying concrete to the casting areas nor the production of more fresh concrete than can be placed at any one time.

To obtain an even distribution of light over the working space, hipped roof lights, spanning between the arches and 10 ft. wide, extend over the full span of 90 ft.; the ribs of the arches will also act as a reflecting surface to assist in eliminating glare which will further be reduced by the "Venetian blind" effect of the longitudinal monorail tracks.

Essentially, therefore, the two buildings consist of series of 15-ft. wide arches of V-section, supported on tapering V-section columns, with hipped lights bridging between the arches and with glazing between the columns to within 4 ft. of the floor, the remaining depth being filled in with brickwork. The cables joining the springings of each arch also tie together at their lower ends the 14 hangers from which are hung the pre-cast beams of 25-ft. span carrying the monorail tracks.

Sufficient heat to give an equable working temperature will, it is considered, be provided by the heating required for the rapid curing of the pre-cast concrete, and no other source of heat is to be installed. The glazing bars in the roof lights are, however, designed so that double glazing can be fitted.

The V-formations of the roof eliminate the necessity for separate gutters, as the rainwater from the lights and the arches is carried in the natural shape of the roof to the down pipes at each column.

DESIGN AND CONSTRUCTION OF THE FRAMES

Each frame consists of 22 pre-cast elements, as shown in Fig. 1; there are 14 identical elements, 6 ft. long by 15 ft. wide, together with two end blocks, forming the arch itself and there are three V-section tapering elements in each column. To reduce their weight for handling, the elements forming an arch are ribbed on their upper surfaces and the spaces thus formed are filled with concrete after erection. Four cables form the tie between the springings of an arch, and there are four external cables to each column. These column cables are anchored at the top in the corner element between arch and column, and at the bottom in the *in-situ* base of a column.

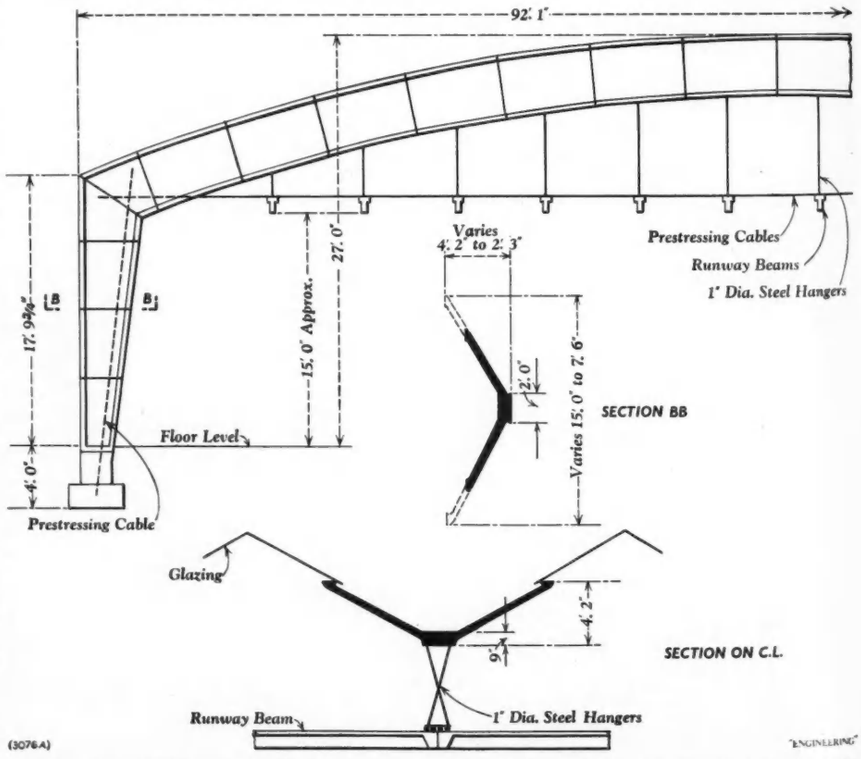


Fig. 2 Half-elevation of a main frame, and cross-sections through the column and arch, the latter section also showing the hipped lights and the suspended runway beams.

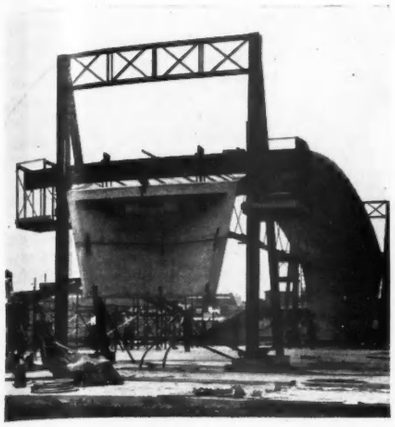


Fig. 3 The arches are made from 14 pre-cast segments which are built on the centreing in the left background. After the cables at springing level have been tensioned, the arches are raised by the lifting frames and the columns attached in three sections.

The frames have been designed to carry the roof loads plus fourteen 1-ton loads from the monorail tracks. The bending moments due to the dead and live loads were first computed assuming the structure to be a monolithic frame. The bending moments due to a unit horizontal force applied to the corners of a frame were then calculated, and it was thus possible to determine a prestressing force to be applied by the tie such that it imposed on the frame a bending moment equal but opposite in effect to that due to the dead loads plus one-half the live loads. In the final condition, therefore, when the live loads are not acting, the frame is subjected to a bending moment tending to deflect the arch upwards, and, when the live loads are acting, to a bending moment tending to deflect the arch downwards; the bending moment causing either of these deformations is one-half of the total bending moment due to the live loads only. Consequently the maximum stresses in an arch, due to working loads, will be extremely low, being about 350 lb. per square inch in tension or compression. The prestressing cables in the columns are located so as to impose no bending moments on the frame. Having determined the prestressing force required in the completed structure, about 200,000 lb., it was necessary to determine the order in which the cables were to be tensioned having regard to the method of erection. The horizontal and vertical cables are contained in metal sheaths and will be grouted when the work is complete.

ERECTION OF THE FRAMES

The pre-cast elements are being cast in timber moulds on the site in positions as near as possible to the frames of which they will form part.

The method of erection, illustrated in Fig. 3, above, is to place on a trestle at ground level the elements forming the arch, make the joints between adjacent elements and, after the joints have hardened, to stress two of the four cables joining the springing of an arch. The arch is then raised by hydraulic jacks, and the column elements attached as the arch is raised. Finally the complete frame is lowered on to its bearings and the column cables are stressed.

The light trestle on which the arch elements are first placed is of tubular scaffolding with a central steel joist as a bearer. It is mounted on wheels for ease of moving. A steel lifting frame is bolted to the elements which can then be tilted easily from the vertical position as cast to the horizontal position as placed. The elements are raised by a mobile crane; between the crane hook and the frame there is a hand-operated hoist which allows an element to be lowered accurately into position and the elements are aligned and levelled on the trestle by means of timber chocks and packings. The elements are spaced 1 in. apart and the gaps filled with a 3 : 1 mortar of sand and high-alumina cement before the voids between the ribs in the arch elements are concreted. After two of the cables have been tensioned the arch is raised by a steel lifting frame at each end.

The two lifting frames each consist of two braced columns of steel channels placed back to back, with an 8-in. space between them for an 18-in. by 6-in. lifting joist and the bearing plates for hydraulic jacks. Attached to the lifting joist is a platform for the men operating the jacks, and this is raised with the arch. The bearing plates are held in position by steel pegs passing through holes in the webs of the columns. The four jacks, working between the bearing plates and the lifting joists, raise the arch (and the men) 9 in. at a time. The lifting joists are then pegged to the columns, the jacks removed and re-treated, and the bearing plates lifted to the next position for another 9-in. lift, all the work being done by the men on the platforms. When the arch is raised sufficiently a column element is fixed below the corner elements, or to the previous column element, by steel angle cleats. When the frame is raised sufficiently to be completed by the addition of the third and bottom column elements, the joints between the column elements are made, the frame lowered on to a mortar bed and the four vertical cables in each column stressed after the mortar has hardened. The third horizontal cable will be tensioned after half of the remaining dead loads are added, and the fourth horizontal cable when all the dead loads have been added.

This method of construction has allowed two frames to be erected each week.

The architects are Taylor & Young, 195 Oxford-road, Manchester, 13; the development of the structural system for the main factory and the civil and structural engineering generally are under the direction of Dr. D. D. Matthews, chief engineer of the owners, Matthews & Mumby, Limited, who are themselves carrying out the work, and the cables and apparatus for prestressing are supplied by the Prestressed Concrete Equipment Company, Limited, 76 Victoria-street, London, S.W.1.

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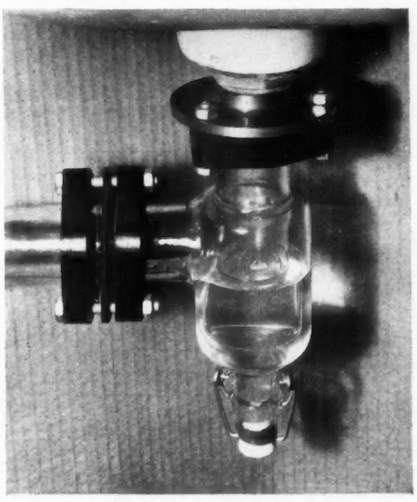
SINK TRAPS MADE OF GLASS

Particularly suitable for laboratories in schools, colleges and elsewhere are the glass sink traps that are now being made by Q.V.F. Limited, Mill-street, Stone, Staffordshire, a member of the Triplex group of companies. The advantages are a greater resistance to chemical wastes than is offered by the conventional metal traps and that blockages, readily seen, can be removed before any damage is incurred.



Glass sink traps offer a high resistance to chemical wastes and blockages can be seen and removed before damage results.

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Teeth of high-speed steel enable holes up to 2 in. in diameter to be cut in plates $\frac{7}{16}$ in. thick at a high rate.

TREPANNING TOOL

An operation frequently encountered in metal working is that of cutting fairly large holes in sheet material. A trepanning tool for this purpose, which is designed for use in bench or portable power drills, has recently been introduced by Dixon-Lesley Limited, 28 St. Mary's-place, Newcastle-upon-Tyne. One size is shown in the illustration.

A $\frac{1}{4}$-in. pilot drill held in a parallel or tapered mandrel centres the cutter in the work. The three cutting teeth are removable and when in use are supported by fixed backing pieces. The latter also control the depth of cut and therefore the rate of feed. The teeth are made of 18 per cent. tungsten-cobalt tool steel, allowing a cutting speed of 120 ft. per minute with mild steel, equivalent to about 210 r.p.m. for a 2-in. diameter hole. For hard steels this rate should be halved and a lubricant used. With other materials faster speeds are possible.

The teeth can be sharpened by hollow-grinding the ends on a 6-in. diameter wheel. A top rake of 2 deg. is used. Six sizes of cutter are made, for holes with clearance diameters from $\frac{3}{4}$ in. to 2 in. The parallel mandrel can be held in any chuck with a capacity of $\frac{1}{2}$ in., and the tapered mandrel can be either No. 1 or No. 2 Morse. Both teeth and pilot drills are replaceable. Standard models will cut holes in plates up to $\frac{7}{16}$ in. thick; plates of $\frac{7}{8}$ in. thickness can be holed by working from both sides using a common pilot hole.

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ADJUSTABLE PACKING

An ingenious form of adjustable packing, particularly suitable for machine shops, has been introduced by Rubert and Company, Limited, Chapel-street, Stockport-road, Levenshulme, Manchester, 19. It consists of two steel strips which fit together by means of a series of parallel serrations cut in one face of each. These serrated faces are inclined, and the serrations are at an angle, so that an infinite adjustment is obtainable by altering the relative position of the strips.

SMALL MARINE DIESEL ENGINE

TWO-CYLINDER MODEL WITH CLOSED-CIRCUIT WATER COOLING

The latest addition to the range of marine Diesel engines made by John I. Thornycroft and Company, Limited, Thornycroft House, Smith-square, London, S.W.1, is the RJD/2 which is a low-powered medium-weight engine designed for use in unskilled hands. The port side of the engine is shown in Fig. 2 and a longitudinal section in Fig. 1.

The RJD/2 is a two-cylinder engine of 3⅜-in. bore by 4½-in. stroke. It has a compression ratio of 16·6 to 1 and a maximum output of 16 shaft horse-power at 1,800 r.p.m. when driving an 18-in. diameter propeller and the heavy-duty output is 12½ shaft horse-power at 1,500 r.p.m., driving a 19-in. diameter propeller. The dry weight, including reversing gear, is 780 lb. The engine is designed to use light-distillate gas oils which conform to B.S. 209 (1947) Class A requirements and the approximate consumption at maximum output (16 shaft horse-power) is ¾ gall. per hour.

A four-stroke cycle is used, together with direct injection. The combustion chamber is in the crown of the light-alloy piston, and is of the Thornycroft patent design. The engine will start from cold without the use of heater plugs or other aids. Separate C.A.V. fuel pumps, visible in Fig. 2, driven from the camshaft, supply each cylinder, and the injectors are of the multi-hole type. Delivery is controlled by the throttle lever (mounted near the starting handle) and by the centrifugal governor which runs at 1½ times engine speed. The linkage to this can also be seen in Fig. 2. This arrangement allows close control at both high and low speeds, which is particularly useful in craft where slow running is sometimes essential. A fuel feed pump with a hand priming plunger avoids the necessity for a gravity feed from the fuel tank. A fuel filter is fitted in the line just before the injector pumps.

The aluminium-alloy pistons have a chromium-plated top ring and two other plain compression rings. Oil control is by two scraper rings, one above and one below the gudgeon pin. The latter is hollow and works in a bronze bush in the small end of the connecting rod. The big end has lead-bronze shells while the rod itself is a steel stamping.

A cast alloy-iron crankshaft is used, statically and dynamically balanced, running in three copper-lead bearings. The camshaft and its integral cams are also of cast iron, chilled and ground to size. It is driven by spur gears from the crankshaft. Push rods from the cam followers operate the rocker gear which is enclosed by a removable cover attached to the cylinder head. The inlet valve is masked to improve combustion. Monobloc construction is employed for the cylinder block and crankcase, the material being chromidium iron with dry liners. The cylinder head, which carries the valves and valve gear, is of the same material. It can be easily removed for decarbonising and for grinding-in the valves.

Lubrication for the various parts is supplied by a force-feed system which is fed by a plunger pump driven by an eccentric on the camshaft. The inlet for this pump, as may be seen from Fig. 1, is almost at the bottom of the crankcase and is so arranged that the pump is always primed. The forced supply lubricates the main and big-end bearings, the overhead valve gear and the combined reverse-reduction gear. The little ends and the cylinder walls rely on splash feed. Oil in circulation passes through a filter in the main feed line and is strained through a gauge before returning to the sump. A hand pump is fitted for the removal of used oil. The question of fume scavenging has been considered in order to minimise condensation and sludge formation.

CLOSED-CIRCUIT COOLING

A closed-circuit system of cooling using fresh water has been adopted, as a controlled operating temperature can be obtained which gives more efficient engine operation with a reduced rate

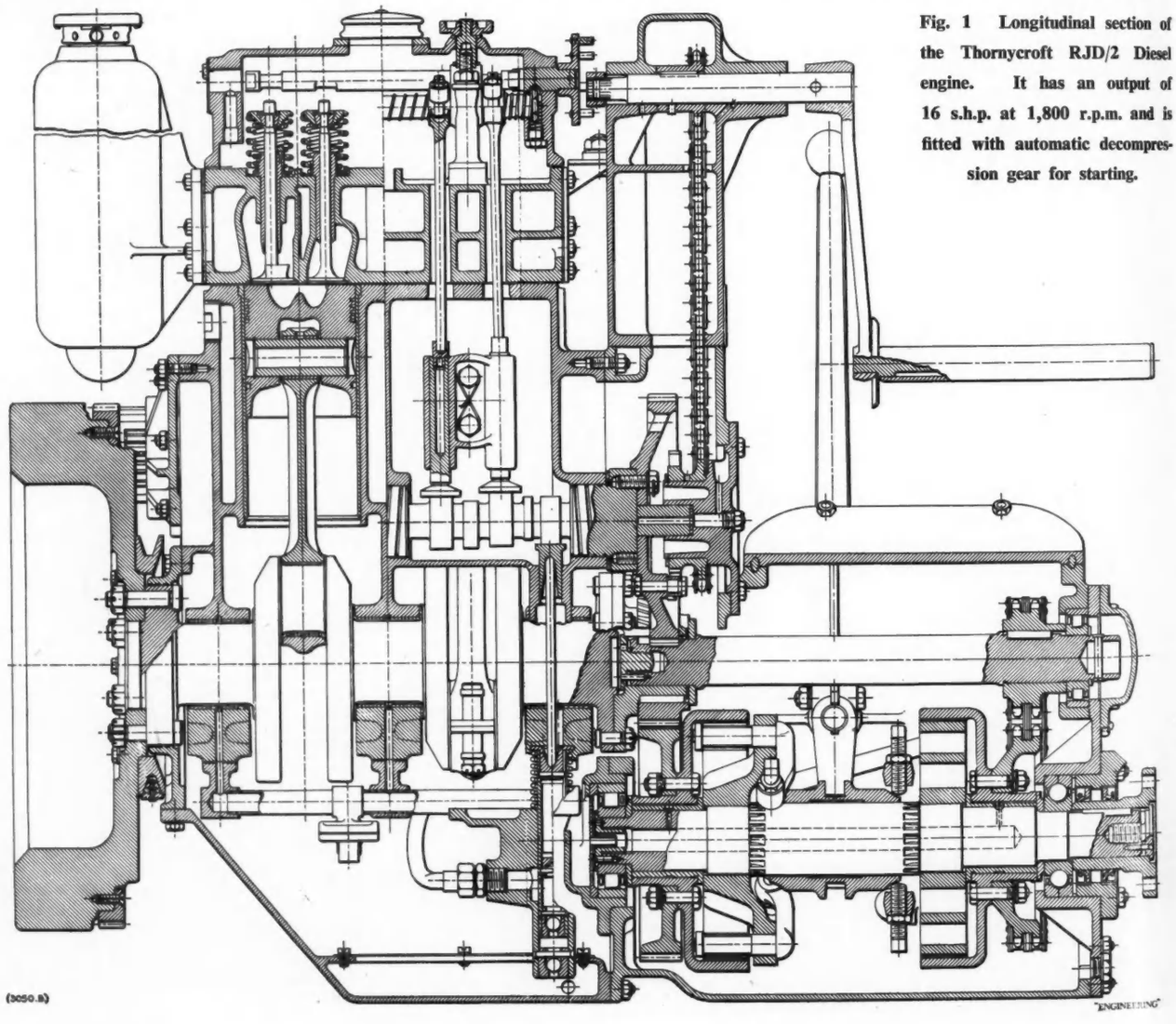


Fig. 1 Longitudinal section of the Thornycroft RJD/2 Diesel engine. It has an output of 16 s.h.p. at 1,800 r.p.m. and is fitted with automatic decompression gear for starting.

of wear. In addition, the life of the cylinder jacket and piping is increased due to the exclusion of salt water and sand. The standard system employed has an external heat exchanger of simple form fitted to the outside of the boat's hull. The construction of the exchanger is sufficiently robust to withstand a blow from a floating object, and the design is intended to give only negligible under-water resistance. Fresh-water circulation is maintained by a large-capacity centrifugal pump which is driven by the same shaft as the engine governor. The standard version of the engine has a dry exhaust with a water-jacketed silencer. A water-cooled exhaust system can be fitted if required. An internal heat exchanger can be supplied for fitting to those craft for which the external exchanger is not suitable.

The drive to the propeller shaft is through a reverse-reducing gear and expanding friction clutches. Control of the operation is by a lever mounted on the starboard side of the engine. The mechanism used is the same as that employed in earlier engines, namely, a gear drive for one direction and a chain-and-sprocket-wheels for the other. Lubrication is common with the rest of the engine, and weirs in the gear casing maintain the proper level of oil while allowing the excess to return to the sump. The reduction ratio in either direction is approximately 2 to 1, the exact values being 35 to 18 ahead and 57 to 30 astern. The resulting slow tailshaft speed allows a large-diameter propeller to be used. The propeller thrust is taken by a special race at the after end of the reverse gear.

The standard starting arrangement is by hand and incorporated with the starting mechanism is an automatic decompression device. Part of this can be seen in the longitudinal section, Fig. 1. When the decompression lever has been set by hand, an arm on the end of the starting-handle shaft engages with a pin on the flange so that the valve is released when the starting handle has made a revolution. In addition, by correct setting of the decompression lever, it is possible to prevent release of the valve for a chosen number of turns of the starting handle. In this way, the complication of operating both starting handle and decompression lever simultaneously is avoided. Electric starting can be added if required. Similarly, a dynamo can also be fitted for electric lighting and battery charging. It is also possible to fit a power take-off drive to the forward end which will transmit full power.

The new engine has been designed to be a direct replacement for the DB2, the " Handybilly," and has the same bolt and shaft centres. However, if the RJD/2 is to be used at the higher speed and power, it is advisable to fit new sterngear and a new propeller. The RJD/2 has been approved by the Ministry of Transport for use in lifeboats and passenger-carrying craft. The engine will be exhibited at the Engineering and Marine exhibition to be held at Olympia, London, from September 1 to 15.

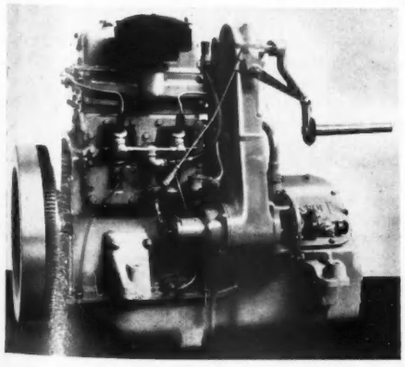


Fig. 2 On the port side of the RJD/2 are fitted the fuel pumps, the governor and the cooling water circulating pump. The throttle lever is also on this side but the clutch is on the far side.

Locomotive-type boilers, mounted on the pneumatic-tyred trailer the rear of which supports the firebox, can be quickly moved from site to site. When in position, the trailer wheels are removed and the trailer becomes the underframe of the boiler.

MAKING BOILERS MOBILE

QUICK TRANSPORT OF COMPLETE UNITS FROM SITE TO SITE

Another special-purpose trailer has been added to the range made by R. A. Dyson and Company, Limited, Grafton-street, Liverpool, 8. Its purpose is to enable the locomotive-type boilers used in oil-well drilling plant to be moved quickly and easily from site to site. The new trailers have been built for the Assam Oil Company, Limited.

In actual fact, the trailers will finally form part of the boiler unit, for the firebox is built on the rear, as may be seen in the illustration. The boiler is secured in place by chains and turnbuckles, and the firebox will be brick lined. Burners will be fitted to use the natural gas available on site. Boiler and trailer frame will thus become virtually a single unit.

On arrival at its destination, the trailer wheels are removed, the front set first. This is done by lowering the landing gear (shown in the "raised" position in the illustration) and releasing the jaws locking the king pin. This action is controlled by a single lever. The front wheels can then be drawn clear. In order to remove the rear bogie, the centre of gravity of the unit has been kept forward so that, when the landing gear is retracted, the forward end tilts downwards, pivoting on the angle of the rear girder. The rear bogie is carried on a single cross-shaft which is released by undoing the clamping bolts. The frame is allowed to tilt far enough forward to enable the rear bogie to be wheeled away, after which the landing gear is again extended and the boiler levelled up. It can then be connected up to the rest of the plant.

Each boiler weighs about 28 tons and the trailer is 41 ft. long. The frame is built up from welded steel sections. The rear bogie has two balance beams oscillating about the central cross-shaft, while the front carriage has two short oscillating axles in line.

* * *

RE-DESIGNED 3-TON BENCH POWER PRESS

The three-ton bench power press illustrated herewith has been designed by Jones and Attwood Limited, Stourbridge, Worcestershire, to replace their former three-ton model. Known as the " Worcester " press, it is intended for bench or floor-stand mounting, and is available for belt drive or fully motorised. When motorised, as shown in the illustration, the press is driven by a ½-h.p. motor, the standard type being suitable for 400/440-volt, 3-phase, 50-cycle current.

The press has a standard stroke of 1 in., with a ram adjustment also of 1 in.; the open too height is 6 in. The bed is 9 in. wide and 6½ in. from front to back. A T-slot extends across the bed, which has a clearance hole 2¾ in. square in the centre. In its standard motorised form the press is fitted with a wire-mesh guard over the flywheel and the V-belts which transmit the drive from the motor. Provision is made for accommodating tool guards of the interlocking type. Tapped holes are provided on the end of the crankshaft and an extension piece can be fitted for operating an automatic feed. The normal form of control is by an orthodox key-type clutch, with a pedal, which is supplied with the press, but it is also possible for a single-stroking attachment to be fitted. The working speed is 150 r.p.m.

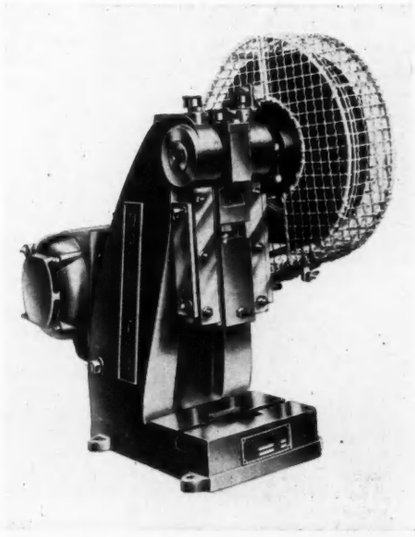
The extra equipment available if required includes a fabricated steel floor-stand and automatic feeds of various types. A crankshaft giving a fixed stroke of ½ in. can also be fitted.

* * *

W. E. HIGHFIELD SHIELD COMPETITION

The W. E. Highfield Shield of the Association of Supervising Electrical Engineers for 1954-55 has been awarded jointly to Mr. G. V. McNeill for his paper on " The Servicing of Fluorescent Lighting Fittings " and to Mr. D. H. Taylor for his papers on " Ultrasonics in Industry."

The Swann Diploma of the same body has been awarded to Messrs. A. E. Allcock, W. R. Gardner and A. A. Lewis and the Association's Technicians' Certificate in Electrical Installation Work to Mr. N. B. Heaton.



The " Worcester " three-ton bench press has a standard stroke of 1 in. and runs at 150 r.p.m.

BAR AND ROLLING MILL

£2½ MILLION INSTALLATION AT STOCKSBRIDGE

Last November, Messrs. Samuel Fox and Company, Limited, Stocksbridge, near Sheffield, a branch of the United Steel Companies, Limited, Sheffield, placed in commission a 60-ton electric-arc furnace which, together with a new raw-materials stockyard, entailed an outlay of nearly £2 million. These developments were described and illustrated in our columns on page 830 of vol. 178 (1954). We now learn that Messrs. Fox are to spend a further £2½ million on a new combination bar and continuous rod-rolling mill and on an associated bar heat-treatment plant. The whole installation is due for completion in about two years' time.

The mill will roll bars and rods in alloy, high-carbon and stainless steels from 0·212 in. to 2½ in. in diameter and equivalent sizes in squares and other sections, including flat material for springs. The new installation is intended to replace an existing looping mill and a 14-in. double-duo mill at the Stocksbridge works, and is being supplied by the Brightside Foundry and Engineering Company, Limited, Sheffield.

The billets destined for rolling in the new mill will first be charged into an oil-fired heating furnace of 25 tons per hour capacity. The furnace is of the continuous-pusher type. Complementary batch furnaces will provide heating facilities for special qualities of steel without interrupting production from the continuous furnace.

The first section of the new mill consists of a three-stand 18-in. mechanised roughing train, two of the stands being three-high units and the third a two-high mill, all being driven from one 1,500-h.p., alternating-current motor. The roughing train is followed by a 14-in. single-stand two-high mill driven by a 350-h.p. direct-current variable-speed motor.

Four 11-in. two-high stands arranged in pairs form the intermediate train, each stand being driven by a 350-h.p. direct-current motor. Next comes an 11 and 14-in. cross-country mill of four two-high stands with individual 350-h.p. direct-current motors to each stand, as in the intermediate train. When rolling bars, the 14-in. stands will be used for the larger sizes and the 11-in. stands for the smaller sizes. Bars will be delivered in straight lengths to a cooling bed and, in addition, two bar reels will be provided to coil all sizes up to 1 in. in diameter or its equivalent.

When rolling rod, the 11-in. stands will be used as an intermediate train delivering the material to a continuous finishing train. This is to consist of a six-stand alternate vertical and horizontal 10-in. mill, designed for rolling all rod sizes. The train is furnished with rod reels, the finished coils being delivered on to a system of cooling conveyors common to the bar reels. Each stand of this mill will be equipped with 250-h.p. direct-current motors and it will be able to roll material at speeds in excess of 3,000 ft. per minute.

All the electrical equipment for the complete rolling-mill installation is being supplied by the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester.

In the bar heat-treatment section of the new plant, facilities will be available initially for the annealing and heat treating of 14,700 tons of material per annum. Equipment to be installed includes two furnaces of 10 tons capacity and four of four tons capacity, the latter being served by a floor-type charging machine. Coke-oven gas firing will be adopted, with the exception of one of the four-ton furnaces which will be electrically-heated. Oil and water-quenching tanks and straightening, reeling and shot-blasting equipment are among other facilities to be provided in this section of the plant, where bars will also be cut to length and inspected prior to dispatch.

See Weekly Survey for Editorial comment.

ADHESIVE CEMENT

The Goodyear Tyre and Rubber Company (Great Britain), Limited, Wolverhampton, announce that supplies of Pliobond adhesive are now available to all types of industry. Pilobond is a synthetic adhesive cement with a wide range of applications. It has been successfully used for bonding wood, metals, plastics, fabrics, ceramic ware, vulcanised synthetic rubber, paper, leather, glass, plaster and Portland-cement concrete. It is used either as a cold-setting glue (Pliobond 30) or, for non-porous materials under heat and pressure (Pliobond 20).

The properties claimed for Pliobond are ease of application; rapid drying and setting (normally 10 to 15 minutes); waterproof characteristics; resistance to dilute acids and alkalies, corrosive salt solutions, and solvents; flexibility and durability; high bond strength; and excellent electrical insulation properties. When dry, it has a low vapour pressure which is useful for vacuum applications. The solvent used is inflammable.

To develop the maximum bond strength, and in the case of non-porous materials such as metals and ceramics, the hot bonding procedure is used, in which Pliobond 20 is applied to both surfaces, which must be cleaned to a bright surface and dry, and allowed to dry thoroughly, either at room temperature or in an oven at 200 deg. F. for 5 minutes. The coated surfaces are then pressed together under a pressure of 100 lb. to 300 lb. per square inch at a temperature of 200 to 300 deg. F. for one minute. The bond will develop its full strength on cooling. Typical bond strengths obtained are as follows: aluminium surfaces, 2,400 lb. per square inch; stainless steel surfaces, 1,800 lb. per square inch; maple to maple, or maple to aluminium, 1,350 lb. per square inch; maple to steel, 1,300 lb. per square inch; birch surfaces, 1,200 lb. per square inch; laminates, 900 lb. per square inch.

Using the cold-bonding cement Pliobond 30, the following bond strengths have been obtained, measured on an inch strip: canvas to aluminium, 25 lb.; canvas to steel, 22 lb.; canvas to canvas, bond stronger than the canvas; neoprene to neoprene, 27 lb.; leather to leather, 42 lb.

Pliobond is not, however, recommended for bonding structural members in continuous shear or tension since it is a thermoplastic and will creep under constant load. Moreover, the bond strength decreases with temperature and at 150 deg. F. is about one quarter of the value at 75 deg. F.

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COLD-CATHODE VALVE

Suitable for Timers and Regulators

Cold-cathode triggering valves have the advantages of a long life during which their electrical characteristics remain stable. They are, therefore, particularly suitable for process timers, over-voltage protection devices and voltage regulators. Unlike thermionic valves they do not require a heater supply nor is there any lag due to warming-up. The Communications and Industrial Valve Department of Mullard, Limited, Century House, Shaftesbury-avenue, London, W.C.2, have recently produced a cold-cathode trigger valve, the Z803U, in which the trigger breakdown voltage remains constant to within 1 per cent. during an operating life of 2,000 hours. The anode voltage is normally 230, but has a range from 160 to 300 volts.

By the use of these valves it is stated that process timers can be constructed with accuracies within 1 per cent., for timing periods between one millisecond and 10 minutes. For over-voltage protection, the valve is used to operate a relay, and for voltage regulation it is used as a combined reference valve and amplifier, since a very small current in the trigger circuit can produce a change of 8 mA in the anode circuit. To maintain voltages within prescribed limits, either two valves can be used, operating at the higher and lower limits respectively, or a single valve can be employed in a self-extinguishing circuit to control a thyratron.

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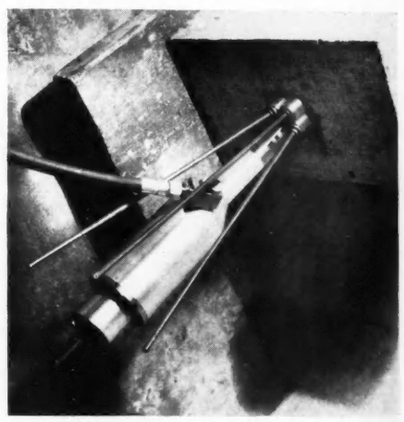
SINGLE-WIRE PRESTRESSING

Light-Weight Equipment for Site Work

Equipment for prestressing concrete that is smaller and lighter than the Freyssinet equipment on which it is based has been introduced by P.S.C. Equipment Limited, 96 Victoria-street, London, S.W.1. Known as the "One-Wire System," 0·276-in. diameter wires are used and these are tensioned one at a time as shown in the accompanying illustration. This illustration shows a four-wire cable and anchorage, but single-wire anchorages are also available and these will be particularly suitable for thin slabs and shell concrete.

The primary advantage of the system is the lightness of the jack that is required for stressing only one wire at a time. The pump, together with the pressure gauge, is fitted into a carrying box and is connected to the jack by a short length of flexible hose. The jack is made of light alloys throughout and has an overall length of only 12¾ in. The maximum travel at each bite is 4 in. and, with a piston area of 6·00 square inch and with the pump capable of developing a pressure of between 2,000 and 2,200 lb. per square inch, an applied load of 15,000 lb. is possible—equivalent to 250,000 lb. per square inch in the wire, a figure perhaps three times that which will be required. The total weight of the pump, which is the only item that has to be moved from wire to wire, is just over 7 lb. A quick-release grip enables the wire to be attached or released from the jack in a few seconds.



Tensioning the wires one at a time requires only a light-weight jack and makes single-wire cables, as well as four-wire cables, a practical proposition for thin slabs and shell construction.

The anchorages have been developed around a single-piece split sleeve which, when forced into the tapered female, holds the wire firm. A feature of the system is that the female part of the anchorage can be embedded in the concrete of the member. Multiple-wire anchorages are available as is shown by the illustration and a special sheath, of square section and designed to retain the wires in their correct positions, can be supplied for these four-wire cables.

UNLOADING RAMP FOR TIPPING LORRIES

Increasing the Size of Dumps

An aluminium unloading ramp capable of taking a 12-ton tipping lorry up to a height of 4 ft., yet light enough to be man-handled with ease, has recently been completed at the Ashton Gate Works of Frederick Braby and Company, Limited, Bristol, 3. Designed for use in stock-piling quartz, the ramp, believed to be the first of its kind, will do a great deal to reduce storage difficulties for Cornwall Mills, Limited, Par, Cornwall, a company whose handling problem is increased by the fact that their quartz is brought only during those months when the Scandinavian ports of origin are ice-free. Their storage problem is one that besets many organisations who handle minerals in bulk. As is well known, if large quantities of material such as ores or coal are unloaded for storage simply by tipping from lorries on to the ground, far more space is occupied than is economical. Unless expensive lifting gear is used, the stockpiles are low and spread over a large area.

By backing the unloading tipper up quite a low ramp, however, the height of the heaped material can be perhaps doubled. With ordinary constructional methods a ramp to take the loads involved is heavy and too unwieldy for easy portability, and it was therefore decided to design and build a special ramp of light alloy. This is of three-part construction, and consists of a 4-ft. high trestle supporting two ramps, each made up of two extruded aluminium channels 2 ft. apart. Cross-pieces of flat strip, set on edge at 6-in. intervals and braced by ties, form the two wheel-tracks. The trestle is built up of channel and angle sections, with diagonal bracing for additional rigidity. All the aluminium-alloy extruded sections are of Noral 51SWP, conforming to B.S. 1476/HE10WP, and were supplied by the Northern Aluminium Company, Limited, Banbury, Oxfordshire. Steel has been used for the top member of the trestle (in the form of a pressing from ¼-in. plate), for the tubular bearers at the top end of each ramp, and for the toe-plates at the lower ends, where lengths of aluminium treadplate form the first 2 ft. 6 in. of track. Cadmium-plated steel bolts were used for fastening throughout, and zinc chromate was applied between aluminium and steel before assembly, to prevent any possibility of bi-metallic action.

When in use, the ramps are secured to the trestle by 1½-in. diameter steel pegs locating in holes in the steel top member of the trestle. Variations in lorry track width are provided by a range of holes spaced 6 in. apart so that the overall track width can be varied in this way from 9 ft. to 6 ft.; the length of angle section used to tie the ramps at their lower ends has a similar provision for adjustment.

For removal to a new position the whole structure can be dismantled in a matter of seconds; the individual ramps are simply lifted from the top of the trestle and lowered on to rubber-tyred aluminium wheels mounted at mid-span and, with the trestle placed on one ramp, both can be wheeled away. Since the overall weight of each ramp is only 6½ cwt., and the trestle is little over 4 cwt., four men can dismantle and erect it without difficulty, and two men can move the dismantled parts with ease. For the aluminium sections no painting is required, and maintenance costs for the ramp are therefore likely to be negligible, in spite of the arduous conditions that may be expected.

This three-part aluminium-alloy ramp, which enables lorries to tip from a height of 4 ft. and thereby increases the capacity of the dumping yard, combines portability with high load-carrying capacity.

* * *

By-laws require that sand and mud shall not be deposited on the roads. It is therefore necessary for the wheels of lorries to be cleaned.

WASHING LORRY WHEELS

Satisfying Local By-Laws

The first of a new type of lorry-wheel washer, now being made by William Moseley (Engineers), Limited, Feltham, Middlesex, was recently installed at the Chertsey, Surrey, headquarters of the Ham River Grit Company. The washer, which is semi-automatic, removes all the mud and clay adhering to the driving wheels of road vehicles operating from quarries, pits or construction sites so that the vehicles comply with local by-laws which require that no mud or dirt shall be deposited on public roads.

The washer, illustrated above, consists of a heavy-duty steel grid in the middle of which are two free-running rollers so spaced that they allow good contact to be made with the rear tyres of an average four-wheeled lorry. The rollers can be locked by means of a hand-operated brake. A pipe running below the rollers supplies through a series of nozzles the water necessary for the washing operation, the flow being controlled by a valve actuated by the brake device already mentioned. The pipe can be connected to the mains supply or, if this is not available, to a pump and storage tank. No other power supply is required. Although the washer is built to withstand the weight of an average four-wheeled lorry, it can be easily moved from site to site as there is only a little pipework and supporting concrete foundations involved in its installation.

The vehicle to be cleaned is driven on to the rollers, the hand brake is released and the water supply valve opened to allow jets of water to play over the rear wheels and around the axle. Top gear is then engaged and the wheels allowed to rotate. In this way mud, clay and stones are thrown clear of the wheels and drop through the grid, the water completing the cleaning operation.

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TRANSLATION OF ELECTRICAL TERMS

First Issue of Bulletin

The first issue of a pamphlet entitled *Electrical Translators' Bulletin* has been produced by the Electrical Translators Sub-Committee of the Aslib Engineering Group. The sub-committee was nominated by the Group for the purpose of promoting co-operation between members in the translation of new terms in the field of electrical engineering. This issue of the bulletin gives a list of recommended dictionaries classified according to language, some translations of new terms, and the names and addresses of contributors to the bulletin. The languages covered at present are Czech, Danish, Dutch, French, German, Hungarian, Italian, Norwegian, Polish, Portuguese, Russian, Spanish and Swedish. The bulletin is circulated free of charge to all members of the Aslib Engineering Group.

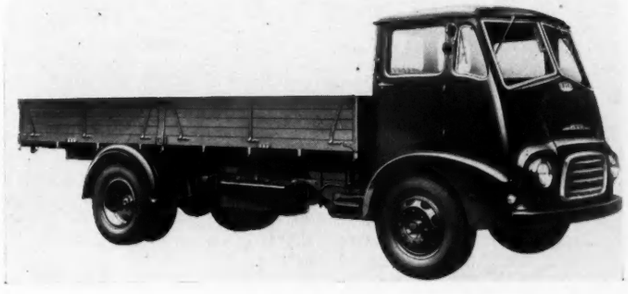
* * *

7-TON DIESEL LORRY

Power-assisted Steering

The British Motor Corporation announced on July 26 that they have produced a 7-ton Diesel lorry to supplement their existing 5-cwt. to 5-ton series. It has a six-cylinder 5·1-litre engine with bore of 95 mm. and stroke of 120 mm., and develops 90 brake horse-power at 2,400 r.p.m.; the compression ratio is 16·5 : 1. A general view of the truck is shown in the accompanying illustration.

The cast-iron alloy cylinder block is integral with the crankcase, and the detachable flanged wet liners are fitted with rubber sealing rings at the lower end. The crankshaft is a heavy-section forging in special alloy steel, counter-balanced and fitted with a torsional vibration damper. The engine drives through a Borg and Beck 12 in. single dry-plate clutch, a gearbox with one reverse and four forward speeds, and an Eaton two-speed rear axle with ratios of 6·14 : 1 or 8·54 : 1. The driver is helped in steering the vehicle by the servo-assistance and the 20-in. diameter steering wheel. The Girling servo-assisted hydraulic brakes operate on 16-in. and 15¼-in. drums (front and rear), and have a total friction lining area of 480 square inches. The capacity of the fuel tank is 20 gallons and the gearbox has provision for a power take-off or a tyre pump.



The B.M.C. 7-ton Diesel lorry has a 5·1-litre engine and develops 90 brake horse-power at 2,400 r.p.m.

Labour Notes

MORE YOUTHS FOR INDUSTRY

Sir Walter Monckton's statement on the work of the Youth Employment Service contains a great deal to cheer the employer who has since the war been driven into a state of despair about his supply of apprentices. In two years the lean period will be over, and for five years, from 1957 to 1962, "industry can look forward to an increased supply of young people." The immediate future is not so hopeful, since the number of school-leavers will be at its lowest in 1956; nor will the increase in numbers be maintained after 1962, when they will go down "almost, but not quite, as before." Thus industry will have for a short time an opportunity to pick out and train a supply of skilled men for its future needs. Sir Walter gives details of the organisation of the Youth Employment Service, which is preparing to meet the anticipated influx of young people. The Service was re-organised after the war by the Ince Committee and is now firmly established. During the last year or two it has become much more accepted by grammar schools, and is consequently being used increasingly. The backbone of the Service is the Youth Employment Officer, about 900 of whom operate the Service locally, visit schools, advise young people on the job that would suit them best and find them jobs. In this way the Ministry of Labour and the education authorities can do much to influence school-leavers in the directions where they are most needed, and they may thus overcome at least some of the prejudice that still exists in too many schools against careers in industry for their better students.

The Central Youth Employment Executive, who direct the Service, have been active in getting industries to agree nationally on schemes of training or apprenticeship. Over 100 such schemes have been agreed, and if these efforts are matched by individual companies a considerable improvement should take place in the supply of skilled men over the next decade.

STOPPING STRIKES

The right of a working man to withdraw his labour is not a matter to trifle with. On the other hand, it carries with it the obligation to exercise the right with a sense of responsibility. According to the Ministry of Labour, there were 1,255 stoppages in the first half of this year, involving 436,000 workers and the loss of 2,795,000 working days—four times as many working days being lost as in the corresponding period of 1954. There is clearly a case for trying to reduce this enormous cost of industrial strife by improving negotiating machinery which will allow reasonableness to prevail, tempers to cool and faces to be saved.

Both the Trades Union Congress and the National Joint Advisory Council have been approaching the problem gingerly. The T.U.C. general council has now decided to put a resolution before Congress at Southport in September modifying Rule 2, clause C, of its constitution to read so that the T.U.C. can intervene in a strike "if there is a likelihood of negotiations breaking down." At present, they can intervene only "in the event" of negotiations reaching deadlock. This device will probably be workable where the big unions are concerned because their general secretaries are close to the T.U.C. secretariat and an invitation to intervene can be easily arranged. It has always been at this point in the trade union movement that the T.U.C. has been most effective in the past. But what will the smaller unions say? Will they favour intervention from the third floor of Transport House? The N.J.A.C., under the chairmanship of Sir Walter Monckton, has decided that the problem of industrial relations cannot be solved by general legislation, and referred back the strike problem (with a series of remedies suggested to it before the meeting) to a special meeting of the Joint Consultative Committee. The N.J.A.C. clearly wishes time to have a considered discussion before tackling at a plenary session the issues raised by trying to stop chronic strikes.

To keep these matters in perspective, it has to be remembered that such solutions as are likely to prove acceptable to both sides of industry are likely to concern the organised worker as a trade union member. There still remains the unofficial strike. There remains, too, the kind of strike which is a manifestation of some malaise which is not getting to the surface and which conciliation machinery is usually ill-fitted to deal with.

RECRUITMENT IN THE MINES

The Ministry of Labour's annual report for 1954 makes only the briefest mention of manpower in the pits, in the context of a decline in the labour force in the basic industries, saying that "coal mining was practically unaffected." Yet coal output has remained almost static at 214 million tons for the last three years and scares of shortages made front-page news several times during this period. Mr. Philip Noel-Baker has suggested that if a vigorous recruitment policy had been pursued, the pits could still accommodate 735,000 miners, 28,000 more than the average number employed in 1954. He points out that the extra cost involved in making the industry attractive—is it only a matter of more pay?—would be small in relation to the cost in terms of foreign exchange of imports of coal at £80 million a year and of oil at not much less. The need of the moment is to save as much foreign exchange as possible, particularly dollars, and Mr. Noel-Baker's views should certainly not be lightly discarded. The Fleck Committee pointed out that there was much to be done to improve recruitment methods, and that pit personnel officers were not always of the necessary calibre. It may well be that the weakness in recruitment lies in this direction more than in wage levels. In this case much could doubtless be done by the Central Youth Employment Executives and its Youth Employment Officers in co-operation with personnel officers at the pits.

Whatever action is decided upon, and it should probably be in several directions, there is little doubt that it must be energetic and intelligent. Failing this, coal output will almost certainly decline once again, with a corresponding drain on our precious reserves of foreign exchange.

DOCK LABOUR SCHEME UNDER SCRUTINY

The appointment of a Committee of Inquiry into the Dock Labour Scheme, announced in the House of Commons by Sir Walter Monckton last week, will be welcomed by every party to these unfortunate disputes and by the principal victim—the general public. The chairman of the Committee will be the Hon. Mr. Justice Devlin, Judge of the High Court, and members will be Mr. J. A. Birch, a member of the T.U.C. Council and General Secretary of the Union of Shop, Distributive and Allied Workers, Sir Frederick Rees and Professor J. G. Smith, eminent university men with much experience of this type of work, and Mr. A. B. Waring, chairman of Joseph Lucas and chairman of the Advisory Council on Research into Problems in Human Relations in Industry. This is a team of men each with an exceptionally high reputation for fair mindedness and objective thinking, well equipped to unravel one of the most confused and explosive situations in British industry. They will doubtless heed Lord Ammon's words in the House of Lords last November, that the Scheme was not functioning entirely satisfactorily and that it should be reviewed.

The reasons given so far for the unrest—communist agitation, mischief-making, union conflicts—have been challenged too often and too convincingly by organisations with a reputation for thoroughness and impartiality to be taken very seriously. Last January, the University of Liverpool published a report of its Department of Social Science (ENGINEERING, January 21) which found that "the legalistic atmosphere of public administration has obscured the realities of what is, in essence, a somewhat simple and very human situation." The Dock Labour Scheme, which was designed to give dockers security of employment, in fact destroyed the working basis of the traditional gang system. The unit, with its foreman-leader, was either at work—or out of work—as a unit. With its collapse the men became isolated and found that the scheme gave them very little in return when there was no work. The result was a great deal of bewilderment and a feeling of having been "let down" by the authorities, among whom the Transport and General Workers Union figured prominently. The T. & G.W. have been quite unable to provide the intimate leadership that would have been required to fill the social vacuum thus created. An inquiry in the London docks by the British Institute of Management at about the same time led to strikingly similar conclusions to those reached in Liverpool. The simple human issues had become lost in a world of "red tape and special pleading."

It is to be hoped that the committee will conduct their business quickly and point out ways in which human dignity in work and the simple but basic need for comradeship will be restored to the Docks.

PROFIT-SHARING SCHEMES IN FASHION

Interest in profit-sharing has flared up again. The movement has, of course, a long history and a mixed one, though there are signs that the number of "live" profit-sharing schemes in industry are growing. For example, in the United States, where the Ford workers recently turned down an offer of this kind, the number of schemes is said to have increased from just over 500 in 1939 to about 25,000 to-day.

In this country, renewed interest owes a good deal to the big and complicated scheme set up last year by Imperial Chemical Industries for its wage-earners and salaried staff. Not long afterwards Dunlop started a scheme. It was perhaps natural that the public and the politicians should see in labour's participation in profits a means of reducing strike action. This has been reflected in a particularly successful annual conference of the Industrial Co-partnership Association at Oxford a few weeks ago; successful, that is, if measured by the number of new faces.

Into this rather favourable atmosphere the Chancellor of the Exchequer recently threw a remark which attracted a good deal of attention and which has been widely misunderstood. In a recent speech he said that the Inland Revenue authorities would help all they could in furthering profit-sharing schemes. We are not concerned here with the fact that the Government is in favour of profit-sharing schemes in general. The point is, what can the Inland Revenue do about it? The answer is, not very much. The Chancellor was, in fact, offering the services of the Inland Revenue to assist in ironing out tax complications when such schemes are at the draft stage. He was not saying that the department would help to push them through; much less was he offering any tax concessions. He was indeed only drawing attention to facilities which already exist. Since then, two other well-known companies have announced schemes—Courtaulds and Rolls-Royce.

Trade-union opinion is divided about the merits of such arrangements to improve industrial relations or as a means of increasing the pay-packet. Both management and labour are, in general, suspicious about some of the theories put forward by the protagonists of profit-sharing, and both are likely to judge their own case very much on its merits as it affects the workers and the company. Labour in this country might well watch the development of profit-sharing in America as against the growth of such contract arrangements as the recent Ford one—for they are likely to be mutually exclusive.